SEP 24

...RING," SEPTEMBER 12, 1924.

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ENGINEERING:

An Illustrated Weekly Journal.

...OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

...OL. CXVIII.—No. 3063.] LONDON: FRIDAY, SEPTEMBER 12, 1924. [Registered at the General Post Office as a Newspaper.] [PRICE ... 1s. BY FOREIGN POST 1s. 4½d.

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Particulars of the proposed amendment were set forth in the Illustrated Official Journal (Patents), issued on the 3rd September, 1924.

Any person, or persons, may give notice of Opposition to the Amendment by leaving Patents Form No. 19 at the Patent Office, 25, Southampton Buildings, London, W.C. 2, within one calendar month from the date of the said Journal.

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F800

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Head of the Department:
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The Directors are prepared to receive

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1. TRACK BONDS.
Fee for Specification, £2 per copy.
Specifications and Forms of Tender (which must be submitted in duplicate) may be obtained at this office on and after 22nd September, 1924, on payment of the fee for the Specification, which payment will not be returned.
The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Bombay, Baroda & Central India Railway Company.
Tenders must be sealed and addressed to the undersigned marked "Tender for Track Bonds," and delivered not later than Noon on Monday, the 13th October, 1924.
The Directors do not bind themselves to accept the lowest or any Tender.
The Consulting Engineers, to whom application for any further technical information may be made, are Messrs. MERZ & MCLELLAN, 32, Victoria Street, Westminster, S.W.1.

S. G. S. YOUNG,
Secretary.

Offices: The White Mansion,
91, Petty France,
Westminster, S.W.1.
11th September, 1924. F 869

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DELIVERY of COUPLING ADAPTERS, FIRE HOSE, HOSE COUPLINGS, GOOSENECKS, NOZZLES, SPANNERS, etc.
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THE SOUTH INDIAN RAILWAY COMPANY, LIMITED, are prepared to receive

Tenders for the Supply of

20 BOGIE OIL TANK WAGONS.
Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.
Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tenders for Bogie Oil Tank Wagons" must be left with the undersigned not later than Twelve Noon on Friday, the 7th November, 1924.
The Directors do not bind themselves to accept the lowest or any Tender.
A charge which will not be returned, will be made of £1 for each copy of the Specification.
Copies of the Drawings may be obtained at the Offices of the Consulting Engineers to the Company, Messrs. ROBERT, WHITE & PARTNERS, 5, Victoria Street, Westminster, S.W.1.

A. MUIRHEAD,
Managing Director.

91, Petty France,
Westminster, S.W.1.
5th September, 1924.

THE BENGAL-NAGPUR RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for:—

AXLE BOXES AND FITTINGS.
Specification and Form of Tender can be obtained at the Company's Offices, 132, Gresham House, Old Broad Street, E.C.2, on or after 5th September, 1924.
A fee of 10s. will be charged for the Specification which is NOT returnable.
Tenders must be submitted not later than NOON on Thursday, 18th September, 1924.
The Directors do not bind themselves to accept the lowest or any Tender, and reserve to themselves the right of reducing or dividing the order.

By Order of the Board,
R. C. VOLKERS,
Secretary.

STATE ELECTRICITY COMMISSION OF VICTORIA.
Melbourne,
Victoria,
AUSTRALIA.

Tenders are Hereby

Invited for the SUPPLY, DELIVERY, etc., of the following for the Yallourn Power Scheme.
Copies of Tender Form and Specification will be available upon application to:—
AGENT-GENERAL FOR VICTORIA,
Melbourne Place, Strand,
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R. LIDDELOW,
Secretary

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R. LIDDELOW,
Secretary.

THE MACHINE TOOL AND ENGINEERING EXHIBITION.—II.

WE continue below the account, commenced in our last issue, of some of the tools to be seen at the Machine Tool and Engineering Exhibition at Olympia. On this occasion, apart from lathes and drilling machines, which form the two classes of machine tools in most general use and are naturally therefore very prominent at the Exhibition, we are dealing with types of tools not touched upon in our first article. Among the rotary motion tools we thus include in our notice this week milling machines, with further examples of lathes and drills, after which we pass on to reciprocating tools such as shapers, planers, slotters, &c.

MILLING MACHINES.

The "Rigid" milling machine, forming part of the exhibit of Messrs. Crossley and Co., St. Mary's Gate, Manchester, is an interesting development of the knee type of machine designed to give greater support to the table with a view to taking the heaviest cuts. The actual machine we illustrate in Fig. 66 annexed has a table 60 in. by 18 in. with automatic longitudinal, cross and vertical feed. The machine is of the single-pulley type driven by a 22-h.p. motor. It will be noticed that the table is supported between the body slide and an outer column surrounded by a long sleeve. The column is carried right up to the usual overhanging arm so that the arbor receives much better support than is possible with the ordinary arm and braces. The upper part of the column is removable, and the operation of opening and closing it can, it is said, be performed in five seconds. The distance between the column and pillar is 28¾ in. and maximum between arbor and table 19 in. The table has a vertical adjustment of 19 in. The cross traverse is 9½ in. and longitudinal feed 37 in. All these are automatic, or can be operated by hand or quick power. One lever only controls the quick-power traverse for all three movements. The machine gives a choice of 16 spindle speeds, the changes being obtained by two dial levers on the column, an index plate giving the required combinations. The range is from 18 r.p.m. to 450 r.p.m. The number of longitudinal feeds available is also 16, extending from 0·563 in. to 23·5 in. per minute. The rapid table longitudinal traverse is at the rate of 78 in. per minute, while for the cross and vertical motions the rate is 39 in. per minute. The driving gears are cut on the Maag principle, and are of chrome-nickel steel, hardened, both for speeds and feeds. The main pulley clutch is conical. The keys are solid with the shaft. All bearings are fitted with bronze bushes, those for the spindle and arbor being adjustable.

Central oiling is arranged for all ordinary bearings. The spindle drive in the column is lubricated automatically by a pump. The sliding surfaces of knee and table are also automatically lubricated. Owing to the long sleeve support given to the knee on the outer column, a longer table than usual can be employed with this machine, without fear of twist, the table being held very rigidly, while at the same time it can be elevated instantly. As an instance of the class of work this machine is capable of it is stated that on 50-ton tensile steel with a cutter speed of 60 ft. per minute, taking a cut 2½ in. wide by ¼ in. deep, it can remove 12 cub. in. per minute, the machine absorbing 15 h.p. On cast iron the rate is 24 cub. in. per minute, and with an inserted tooth cutter 450 lb. of cast iron can be removed per hour. At the same time the machine is suitable for light work.

Messrs. James Archdale and Co., Limited, Birmingham, have three all-gear single-pulley milling machines running with gear-box covers replaced by glass, so that the interior mechanism and the effectiveness of the lubrication system can be examined. One of the smaller machines we illustrate in Fig. 67 herewith. This is a moderate-size horizontal milling machine of very neat appearance, capable of rapid handling and quick cutting. The size of the work table is 25 in. by 10 in., the maximum distance from spindle to table being 16 in., and from spindle to steady arm 5 in. The maximum distance from spindle nose to arbor support with the brace in position is 13 in. The diameter of the spindle in the front bearing is 2⅝ in. and that of the steady arm 3¼ in. The drive is by constant speed belt on to a pulley at the head of the column, a clutch coupling up with a gear-box giving six changes of spindle speeds ranging from 36 r.p.m. to 455 r.p.m., obtainable by two levers on the side cover of the gear-box. The gears are of hardened steel and are automatically lubricated by pump. The spindle runs in phosphor-bronze bearings automatically lubricated. The front bearing is conical and the back one parallel. The spindle is hollow, allowing for the use of a draw bolt for the arbor.

The feeds are taken direct from the main gear-box and are four in number, ranging from 1·52 in. to 6·13 in. per minute, the changes being secured by means of the left-hand bottom lever on the gear-box cover. The feed, transmitted from the box by a vertical spindle, is carried to the table by an horizontal spindle on the knee. The worm is of phosphor-bronze, the other gears being of steel. The feed screw on the table is of quick pitch, and is fitted with ball thrust bearings. Ball thrust bearings are also fitted to the worm and the elevating screw. The slide movements are provided with indicating collars. An automatic knock-off is fitted to the feed to prevent damage by over-running of the table. The 9-in. driving pulley runs at 400 r.p.m.

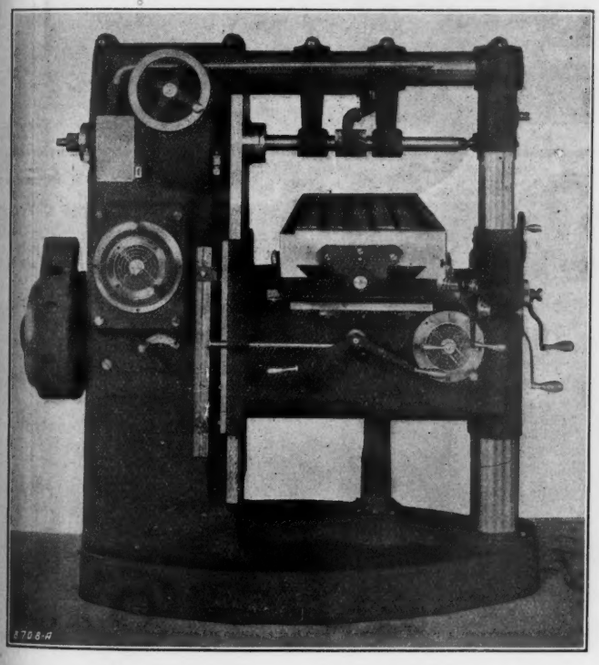


FIG. 66. HORIZONTAL PLAIN MILLING MACHINE; MESSRS. CROSSLEY AND CO.

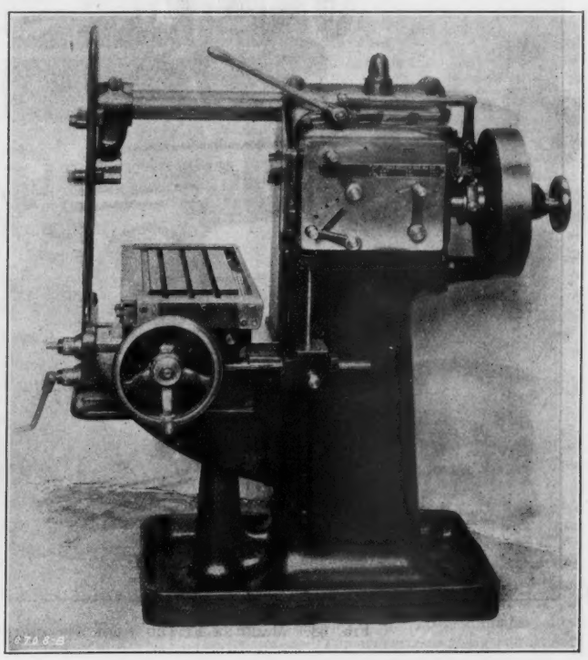


FIG. 67. HORIZONTAL PLAIN MILLING MACHINE; MESSRS. JAMES ARCHDALE AND CO., LIMITED.

VERTICAL MILLING MACHINE AT THE MACHINE TOOL EXHIBITION.

CONSTRUCTED BY MESSRS. JAMES ARCHDALE AND CO., LIMITED, ENGINEERS, BIRMINGHAM.

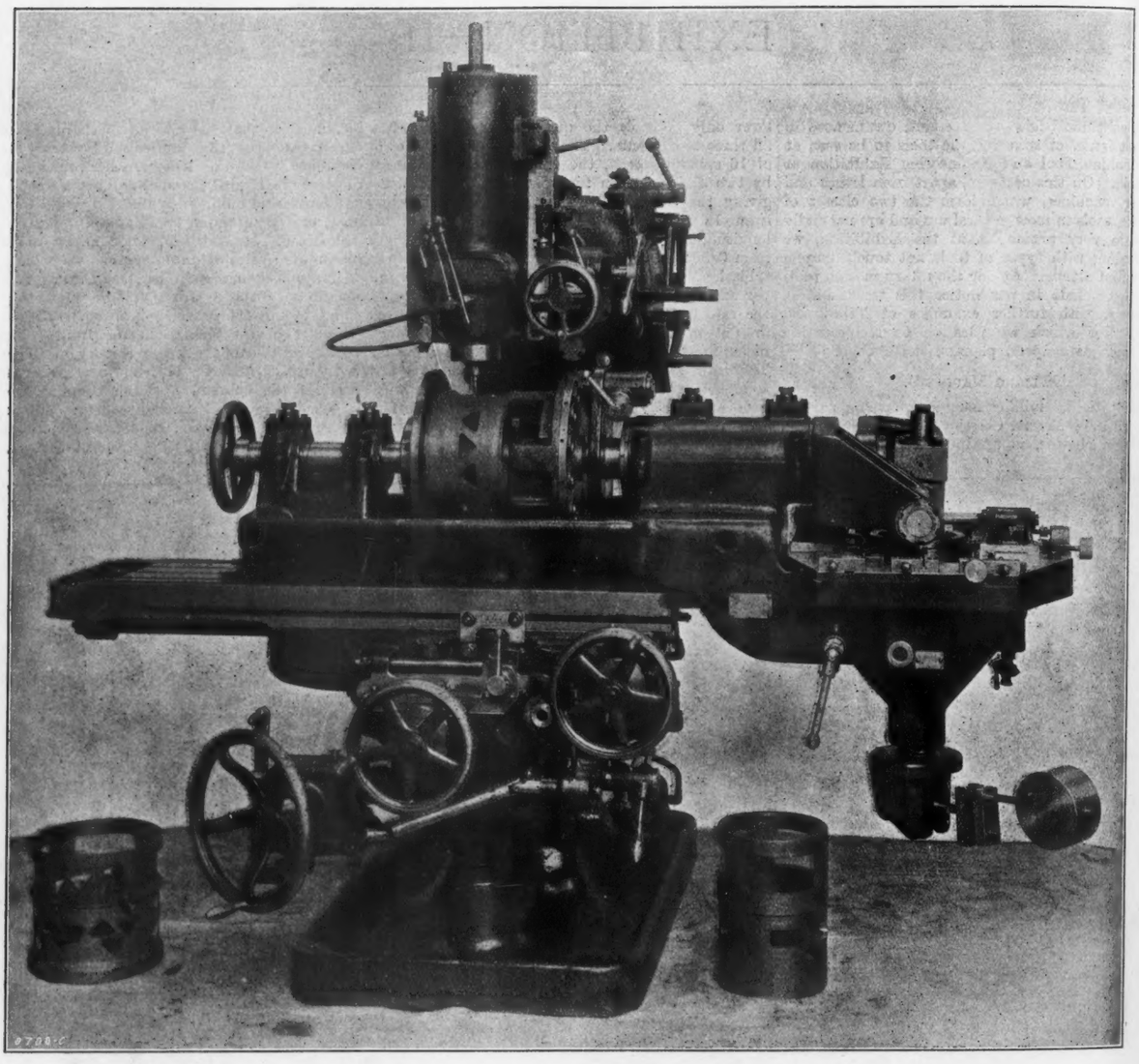


FIG. 68. MACHINE FITTED WITH ATTACHMENT FOR MILLING PORTS OF PISTON VALVE LINERS.

The machine takes 3 h.p. to drive it. Under test conditions on mild steel, a cut 3 in. wide by 0·269 in. deep can be taken at a feed of 6·13 in. per minute.

A second machine is a rather heavier horizontal model with a table 37 in. by 11 in. wide. This machine is also of the single-pulley constant-speed belt type. The pulley is 12 in. in diameter by 3½ in. and running at 400 r.p.m.; the machine takes 4 h.p. to drive it. The spindle diameter in this case is 3½ in. in the front bearing and the steady arm has a diameter of 4 in. In this tool the six spindle speeds are very similar to those in the machine described above, but the four feeds are rather heavier, ranging from 2 in. to 7·38 in. per minute. Some interesting tests have been made with this machine. In one instance, with one of Messrs. Kendall and Gent's inserted blade cutters, a variety of which are to be seen at that firm's stand at the Exhibition, a cut 4 in. wide and 0·28 in. deep was taken on 28-ton mild steel, at the highest feed, namely, 7·38 in. per minute, the metal removed being 2·33 lb. of chips per minute. With a spiral-nicked cutter 3½ in. in diameter by 4 in. wide, and cutting speed of 83 ft. per minute in cast iron, the metal removed ranged up to 10·8 cub. in. per minute with a depth of cut of 0·372 in. Over a number of runs the cubic inches removed per 1 h.p. per minute averaged 1·17. In another series on mild steel the cubic inches removed per 1 h.p. per minute was 0·8, the maximum cut being 0·213 in. with a feed of 7·3 in., or 0·426 in. with a feed of 3·15 in. per minute. With double-spiral cutters, 3½ in. in diameter by 4 in., and cutting speed of 77 ft. per minute, the cubic inches of cast iron removed per horse-power per minute were 1·425, the maximum depth of cut being 0·372. For mild steel, with a maximum depth of cut of 0·213, the amount reached 0·765 cub. in. per horse-power per minute. The machine shown is fitted with automatic vertical feed to the table, but this is not always provided.

The third machine exhibited by Messrs. James Archdale and Co., Limited, is one of their well-known 30-in. verticals, of which we gave a number of illustrations on the occasion of the last Exhibition (see ENGINEERING, vol. cx, page 334). This is an excellent machine capable of a large range of work. Its adaptability to special jobs is well illustrated at the Exhibition, where it is shown arranged with an attachment for the milling of the ports of piston valve liners for locomotives. The arrangement is similar to that shown in Fig. 68. This machine has a longitudinal traverse for the table of 30 in., and cross traverse on the knee of 12 in. The vertical table feed is either automatic or by hand, through a distance of 18 in., while the spindle head is on a slide and is capable of a vertical movement of 6 in., by hand only. The table measures 44 in. long by 14½ in. wide and the maximum distance from the spindle to the table is 20 in. From the centre of the spindle to the column the distance is 20 in. The machine is usually fitted with a circular revolving table 16 in. in diameter, when the maximum height from the table surface to the spindle nose is 14¾ in. The spindle has a diameter of 3½ in. in the bottom bearing. The drive is through constant-speed single-pulley and clutch to a gear-box giving 18 speeds, ranging from 28 r.p.m. to 630 r.p.m. controlled by the combination of three levers. An index plate is fixed to the gear-box. The spindle head is balanced. The machine also has quick and slow hand adjustments and is provided with micrometer stops and an index.

The feed drive is taken by worm gear off the main pulley spindle, by vertical shaft to a gear-box giving nine rates of feed for the longitudinal and cross-traverse movements of the table. These changes are obtained with two levers in combination with sliding gears. The feeds are from 0·86 in. to 12·4 in. per minute; all are reversible, the control being by lever accessible from either the back or front of the machine. Hand traverse is provided, of course, in addition to power traverse, while the circular table, when fitted, has both hand and power rotary movements. All these motions are derived from one horizontal shaft from the feed gear-box.

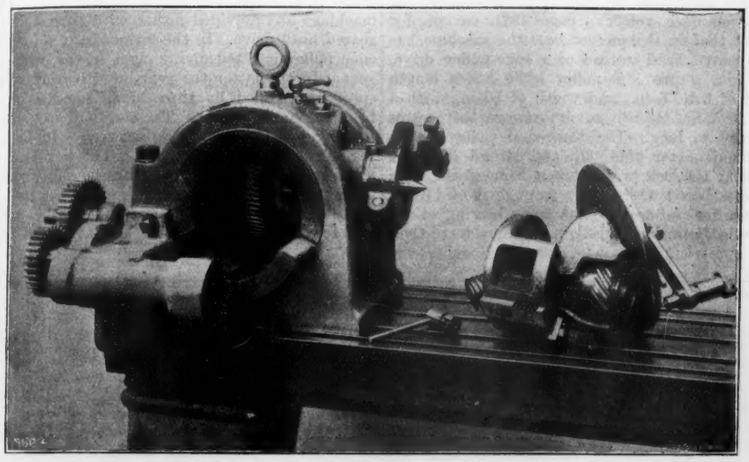


FIG. 69. UNIVERSAL MILLING MACHINE DIVIDING HEAD: MESSRS. J. PARKINSON AND SON.

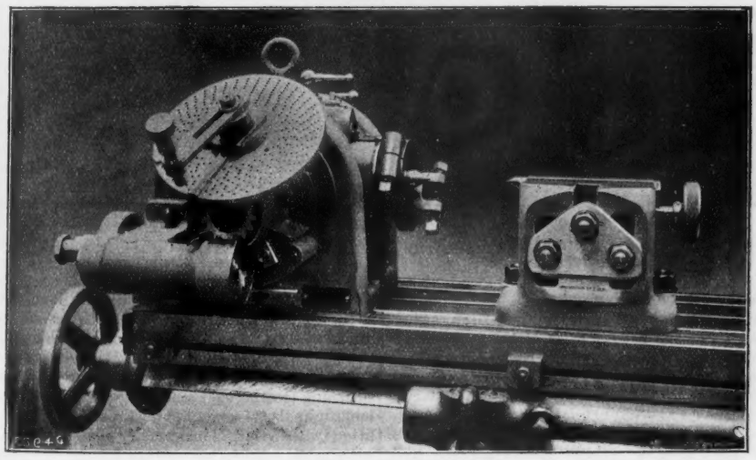


FIG. 70. COMPONENTS OF DIVIDING HEAD; MESSRS J. PARKINSON AND SON.

A safety arrangement is fitted to the feed to prevent damage in case of accident, and safety stops to prevent over-running of the table. Automatic knock-offs and dead stops have been included for all motions.

When arranged for milling piston-valve ports, as shown in Fig. 68, a large attachment is fitted to the table. This consists of a base on which are mounted two face plates on shafts carried in bearings. The liner to be milled is mounted between these two plates, of which the right-hand one serves for indexing, being provided with bushed holes into which is pushed a plunger on an arm on the right-hand shaft. At the outboard end of the latter is a cam roller on a vertical spindle, driven by worm wheel and worm and a telescopic shaft. This shaft is belt-driven off an extension to the feed-box. The roller makes contact with cams set on an horizontal plate, and rocking and longitudinal movements are thereby imparted to the work. Separate cam settings are needed for triangular and rectangular openings. The cams are inexpensive and can be arranged to give any size and shape within the capacity of the machine. After the depth to be milled has been adjusted the action is automatic, and when an opening is finished the operator has merely to index the work by means of the bushed face plate and plunger and restart the feed. The guiding faces are all hardened. The worm-wheel shaft is provided with ball-journal and thrust bearings, while the cam-roller pivot is also carried on a ball bearing.

As an example of the work done with this attachment, the output may be quoted for liners with six rectangular 1½-in. openings, four of which were 4$\frac{9}{16}$ in. long and two 3 in. long, and 14 triangular openings of 2¼-in. sides. The complete port with six rectangular openings was machined from the solid in 45 minutes, while the port with triangular openings was completed in 2½ hours floor-to-floor time.

Messrs. J. Parkinson and Son, Shipley, are naturally exhibiting milling machines and gear planers. Of the former, they are showing two of their standard types, one a plain milling machine and the other a universal. Both are single-pulley machines with constant speed belt-drive. The universal machine has a table 49 in. by 10 in., and table movements of 28 in., 12 in., and 18½ in. for longitudinal, cross and vertical motions, respectively. At the time of the last Exhibition we gave a description of a rather larger machine of this class, shown by Messrs. Parkinson, while on another occasion in that year we went into more detail with regard to certain features of the design.* We need scarcely, therefore, enlarge upon these points afresh. The plain milling machine shown has a table measuring 64 in. by 14 in., with longitudinal table traverse of 40 in., cross traverse of 12 in. and vertical adjustment for the knee of 20 in. The single pulley is 20 in. in diameter, and it runs on ball bearings at 340 r.p.m., being intended for a 4½-in. belt. A friction clutch is combined with the pulley, controlled from the front or side of the machine. The gear drive to the spindle is similar to that illustrated in the article above referred to. The gear-box provides 16 spindle speeds, ranging from 14 to 340 r.p.m.; the spindle has a large taper bearing at the front, 6½ in. long, and a parallel bearing 4¾ in. long at the back. The feeds are also 16 in number from ½ in. to 14·8 in. per minute. The feeds are derived from the constant-speed shaft, and are independent of the changes used for the spindle speed. Index plates are provided for both the speed and feed gear-boxes, the former box being operated by three levers and the latter by two. In addition to the cutting feeds, quick power traverse is arranged for all movements so that the table and knee can be rapidly adjusted without effort. It is driven by the belt driving the feed and can be operated when the spindle is at rest. A spindle lock is provided for use when tightening or loosening nuts on the arbors, etc., and is interlocked with the spindle starting-lever.

Hand adjustment of the table is effected by a wheel, the feed screws being provided with large micrometer collars graduated to read to 0·001 in. The hand wheels for the three movements are grouped together in front, that for the elevating motion on the left; the one for the cross traverse in the centre; while that for the longitudinal traverse is diagonal and stands on the right hand. Automatic trips are provided. The machine has a heavy steady arm with movable arbor support and brace to the knee.

The universal dividing head, which forms one of the accessories for Messrs. J. Parkinson and Son's universal type of milling machine, is illustrated in Figs. 69 and 70, annexed. The former shows the head on the work-table, while the latter shows it with the worm and index plate removed. The dividing worm is cut from the solid shaft and afterwards ground. It engages with the worm wheel at an angle, thus allowing the dividing wheel to be of maximum size, while the inclination also brings the index-plate into the position in which it is most easily read, as will be appreciated from Fig. 69. The worm and dividing wheel are entirely enclosed and protected from dirt or damage. This head gives three methods of indexing, by which a very large range is covered: these are direct, simple, or differential. For direct indexing the dividing wheel has 24 holes, which are engaged by a plunger operated by a lever on the top of the head casing. To enable this plunger to be used, the whole worm, plate, and crank mounting shown lying on the work-table in Fig. 70 has to be slid horizontally forward in the casing. Until this has been done the direct indexing plunger cannot be operated. The worm mounting is run forward by a lever and pinion operating a short rack. Both of these parts may be seen in Fig. 70. When re-engaging the worm, the direct plunger must be withdrawn before engagement can be effected. Any backlash which may develop between the worm and wheel is taken care of by setting the worm closer into the wheel.

For simple indexing, which is most commonly used, the divisions are obtained by the plate and crank, the latter operating the worm and worm wheel direct. For differential indexing the crank and index plate are used in the ordinary way, but the division plate must be turned backwards or forwards as necessary. The movement of the crank operates the worm wheel. At the same time, the movement of the plate, to the back of which is fixed a bevel, actuates a second bevel and worm, to be seen exposed in Fig. 70. The latter drives a short shaft and gears, through which the spindle of the head is driven by a special arbor inserted when this form of indexing is necessary. The charts supplied give

* See ENGINEERING, vol. cx, page 268.

particulars for obtaining any number of divisions from 2 to 500.

Messrs. Alfred Herbert, Limited, of Coventry, are showing three of their types of milling machines—namely, a universal machine, a plain milling machine, and a vertical. All these are single-pulley, high-powered machines of the class in which Messrs. Herbert were such noted pioneers. They all possess the general characteristics of Herbert machines, most of which will be familiar to our readers, since we have on several occasions referred to developments of these tools. At the time of the last Exhibition we described and illustrated the firm's vertical machine (see vol. cx, page 334), and subsequently in the same volume (page 834) gave a full description of the plain miller; more recently (ENGINEERING, vol. cxvii, page 491) we have dealt with the latest pattern of universal machine. Examples of each of these are exhibited now at Olympia. All these machines embody ball-bearing, single belt pulley drive to the gear-box, giving 16 spindle speeds ranging from 16·5 r.p.m. to 427 r.p.m. The range of feeds is also similar in the three cases, extending from $\frac{5}{8}$ in. to $22\frac{1}{2}$ in. per minute, in 18 changes. The spindle speeds are obtained by means of two short levers and three crank handles, an index plate giving the correct combinations. The drive to the feed-box is by belt. The changes of feed are obtained by a hand wheel with dial indicator. The main clutch can be operated from in front of the knee, as can also the reverse to the feed, as well as the automatic cross and vertical feeds. The universal machine is fitted with a swivelling slide allowing angular adjustment each side of the centre of 46 deg. The dividing head fitted admits work 29 in. long between centres. Plain and differential indexing is possible for all divisions up to 400, and for selected numbers above.

The knees are similar for the three machines, and generally the controls in front of the knee for the plain and vertical machines are alike; in the case of the universal machine there are necessarily differences. The horizontal machines have heavy overhanging arms, arbor supports and stiff braces, roller steadies being used on the arm. Ball bearings are liberally used. Automatic and safety stops and trips are introduced for all feeds. The gear changes are interlocked and generally the machines are made as fool-proof as possible, and at the same time convenient and simple to operate.

A small milling machine at the stand of Messrs. Drummond Brothers, Limited, of Guildford, is worthy of attention by users who require a handy machine for general work. This tool is intended to meet the needs of garage and other works in which the variety is considerable and the quality expected is good. It is belt-driven by a three-step cone pulley taking a 2-in. belt, and has eccentric back gear. With a 10-in. countershaft pulley running at 250 r.p.m. the spindle speeds range from 16 r.p.m. to 450 r.p.m. From the cone pulley spindle tail a belt drive is run down to a small pulley on the base for driving the elevating gear, the vertical adjustment by hand or power being 20 in. The hand or automatic longitudinal feed is 15 in. at 1/100 in. and 2/100 in. per revolution of spindle. The cross traverse of the table is 4 in. A strong overhanging arm is fitted, this being 3 in. in diameter. One of the special features of the machine is its tilting table. The whole cross-slide and table are carried on a large circular knee, on which they can be tilted to 45 deg. on either side of the horizontal.

LATHES.

As a whole it cannot be said that the display of lathes is characterised quite by the same degree of novelty that was in evidence in 1920. There are, however, a number of very interesting tools, some of quite new design; others are notable developments of former models. In general appearance the lathe is improving steadily, and some of the types now on view convey an impression of real serviceability.

The Colchester Lathe Company has an exhibit of no less than 11 machines, several of which can be seen at work. A neat form of electric drive—not, of course, new now—is to be seen on some of the smaller lathes shown by this company. As an alternative to treadle drive the motors are placed below the bed under the headstock, and drive the machines direct by means of a pinion on the motor spindle which gears with a spur on the periphery of or inside the flywheel.

In Fig. 71, on this page, and Fig. 72, Plate XXXV, we illustrate two examples from among this company's exhibits, deferring our notice of others for the present. The first of these is a $6\frac{1}{2}$-in. centre tool with cone pulley drive; the second a $7\frac{1}{2}$-in. centre lathe with all-geared head. The tools shown range from a 5-in. gap machine to an 18-in. centre surfacing and boring lathe similar to a 13-in. centre lathe we illustrated on the occasion of the last Exhibition (see vol. cx, page 432), except for the fact that in the present case the machine has an all-geared head instead of a cone-pulley drive. The $6\frac{1}{2}$-in. centre cone-pulley lathe has a length of bed of 6 ft. 6 in., and width of 10 in., with a depth of 7 in. It will admit between the centres work 48 in. long. The three-step pulley has a smallest diameter of $4\frac{3}{4}$ in. and largest diameter of $7\frac{1}{2}$ in., the belt width taken being 2 in. The spindle is bored with a hole through it of $1\frac{9}{16}$ in. diameter for rod work. The front bearing of the spindle is $3\frac{1}{2}$ in. long by $2\frac{1}{2}$ in. in diameter. Over the saddle the height of centre is $4\frac{1}{2}$ in., while in the gap the lathe will take work of 20 in. swing. The width in the gap in front of the face plate is 5 in. The feed change box is of the Hendy-Norton type and enables 24 threads from $3\frac{1}{2}$ to 48 per inch to be cut, or 24 feeds from $10\frac{1}{2}$ cuts to 144 cuts per inch.

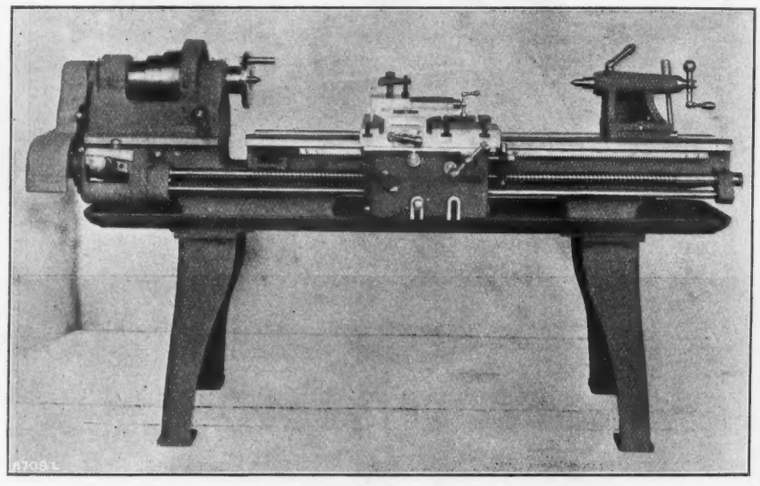


FIG. 71. $6\frac{1}{2}$-IN. CENTRE LATHE; THE COLCHESTER LATHE COMPANY.

The $7\frac{1}{2}$-in. centre lathe illustrated in Fig. 72, Plate XXXV, is a rather more elaborate tool, though again designed on simple lines with a view to ease of handling and making the machine fool-proof. At the same time, every regard has been paid to accuracy and cutting power. This machine has a length of bed of 8 ft., admitting between centres work 45 in. long. The spindle is bored with a hole $2\frac{1}{16}$ in. in diameter, and the front bearing is $4\frac{1}{2}$ in. long by $3\frac{7}{8}$ in. in diameter. The geared head gives eight spindle speeds, ranging from 18 r.p.m. to 250 r.p.m., while the feed gear-box is of similar design to that of the previous machine, but giving 32 feeds of from 8 to 120 cuts per inch; it also enables 32 threads of between 4 and 60 per inch to be cut. Over the saddle the lathe can swing work 11 in. in diameter, and in the gap 24 in., while the clear width of the gap in front of the face plate is 8 in. In this machine the shafts in the headstock, except the main spindle, are fitted with ball bearings. The saddles run on a narrow guide. There is only one handle on the apron for engaging and disengaging the sliding and surfacing feeds. The apron feeds are thus interlocked and one only can be in use at a time, and the gear-box can only be used to give one feed or one screw pitch at a time. Only one gear in the headstock can be engaged at a time. The lead screw is cut from a master screw tested by the National Physical Laboratory, in which the error is 0·00065 in. per foot.

Messrs. Holbrook and Sons, of Stratford, are showing four lathes, two of which are of their tool-room types, while the others consist of an $8\frac{1}{2}$-in. gap lathe with cone pulley drive and a $6\frac{1}{2}$-in. gap engine lathe with geared head. All these lathes have raised vee beds. The lead screws are cut from a master corrected by the N.P.L. at Teddington. The two tool-room lathes have respectively 6-in. and 7-in. centres. The one we illustrate in Fig. 73, Plate XXXV, is the larger of the two. These machines are provided either with cone pulley or geared head drive. In the former case, a four-step cone pulley is fitted giving eight speeds, with back gear. In the latter the gear-box gives 12 spindle speeds controlled by three small handles on the front of the headstock. The standard feed change box gives 36 feeds, ranging between 8 to 420 cuts per inch without loose gears. The box is of the tumbler pattern. Threads can be cut from $1\frac{1}{2}$ to 80 per inch. The four shafts extending from the feed box to the right-hand end of the lathe, are the lead screw at the top; next below is the feed shaft; below this again is the stop shaft, and lowest of all is the reverse shaft. The latter enables reversing of the feed to be controlled from the saddle by the bottom lever on the apron. At the bottom of the apron is also a lever engaging the cross traverse for surfacing (to the left), and one to the right for the longitudinal traverse. The cross slide screw is fitted with a large micrometer dial, and a quick withdrawal self-locking motion for use when screw-cutting, giving a travel of $\frac{1}{2}$ in. The top slide swivels to any position, and is graduated to 45 deg. on either side of the zero. An elevating tool rest enables the tool to be set at the correct height for different diameters without packing. The apron is double walled. A taper-turning attachment forms part of the equipment of this lathe, which is intended for the full range of tool-room work. A relieving attachment is also supplied, driven through change gears off a back shaft. This gear includes a universal shaft drive from these gears to the saddle where the cross slide is under the control of a cam movement.

The well-known lathes of Messrs. H. W. Ward and Co., Limited, of Selly Oak, Birmingham, are shown in three sizes. One machine exhibited is a $6\frac{1}{2}$-in. capstan lathe with $1\frac{1}{2}$-in. automatic chuck, a lathe which is largely used for the production of fire-box stay bolts. The other two lathes are combination-turret machines, one being a 7-in. and the other a 10-in. The latter is illustrated in Fig. 74, Plate XXXV. It is a very powerful machine with single-pulley drive for a 5-in. belt, and with

the firm's patent geared headstock controlled by five levers. The driving pulley is mounted on ball bearings, and the clutch is of the metal-to-metal cone type. The speed-change levers give 16 speeds forward and 8 in reverse. An index plate below the levers shows the various selections. They engage with a slotted plate to eliminate risk of accidental movement. Each lever is connected to the driving clutch as well as to its sliding gear, and depression of the lever releases the clutch. Without this downward movement the gear cannot be moved. Six-spline shafts are used for the sliding gears. Each lever has three positions, one of which is neutral, and all are interlocked to prevent conflicting gears being engaged. The final drive to the spindle is to a gear close up to the front bearing. The spindle speeds in the 10-in. machine vary from 8 r.p.m. to 250 r.p.m. The spindle is of large diameter, having a 5¼-in. hole throughout its length so that the machine can be employed on very heavy bar work.

The saddle allows a swing over the cross-slide of 12 in., and has a longitudinal traverse (automatic feed) of 49 in. The feed gear-box gives a selection of eight feeds for sliding and surfacing, ranging from 15 cuts to 156 cuts per inch traverse. Further, four changes of the lead screw are possible, so that with one leader four different pitches can be cut. The sliding and surfacing and screw-cutting motions cannot be engaged simultaneously, while reversing is arranged for at the saddle. The sliding and surfacing saddle has a square tool turret. The main turret is hexagonal and is mounted on a heavy saddle having a movement of 49 in. on the bed. The turret has 12 rates of feed by a special shaft from the gear-box. The feeds range from 8 cuts to 208 cuts per inch. Quick-power traverse is also available from a constant-speed shaft, from which also is taken the drive for the automatic rotation of the turret. The maximum distance between the spindle nose and the turret face is in this machine 66 in. Stops are provided for longitudinal and cross-traverse movements of the saddle and slide, and indexing stops for the turret, by the splined (bottom) bar extending from the tail towards the headstock of the lathe.

The 7-in. machine is, of course, intended for a smaller class of work, having only a 2⅜-in. hole through the spindle. It is also a single-pulley machine, with Ward geared headstock and control of eight changes of spindle speed in both directions by means of four levers. The saddle has automatic and hand traverse for sliding and surfacing, a choice of ten rates of feed and three changes of the lead screw being possible. Sliding and surfacing movements are interlocked. The turret feeds are 10, by an independent shaft. Automatic stops are fitted for the saddle traverses, while indexing stops are furnished for the turret slide. The bar carrying these is rotated automatically when the turret is rotated, the latter being effected in this lathe by hand and not by power, as in the larger lathe exhibited.

Messrs. Ward's 6½-in. capstan is a cone pulley machine, with a hollow spindle, bored to 1⅝ in. The spindle thrust is taken on ball washers. The lathe is fitted with a capstan rest and cut-off slide. The latter has longitudinal movement by hand wheel, spirals and screw. Adjustable dead stops are furnished. The capstan saddle can be clamped to the bed in any position. The slide has a useful movement of 8 in. Six stops are arranged to index with the turret, which is hexagonal. The turret is rotated by hand. Automatic feed to the turret slide is fitted if required, otherwise the feed is by a large star wheel. The automatic chuck fitted to this lathe is operated by a lever on the side of the headstock, which, by means of a pinion, transmits a rotary movement to a sleeve. As this occurs, owing to spiral slots in the sleeve, in which are guides fixed to the head, the sleeve is advanced. This causes a set of balls in pockets to be forced up a coned surface on a second sleeve of smaller diameter. The latter is coned inside, and contains the split collet. As the balls are pushed on to the exterior conical surface, they force the sleeve forward, and this, in turn, causes the collet to close on to the work.

In our last issue we described the large 18½-in. centre lathe shown by the Selson Engineering Company, Limited. This company is exhibiting two other machines, both of which are very serviceable looking tools. One of these is an 8½-in. centre lathe with single pulley geared head and the other is a 6½-in. centre lathe with cone pulley drive. The former, which is quite a new model, is illustrated in Fig. 75, Plate XXXV. The latter has already been on the market about three years. We understand that both types have already made their way to many distant parts of the Empire, to South America, and numbers of Continental countries. Both combine British and American characteristics. Among the latter may be noted the inverted vee bed, the design of the tool slide on the left side of the saddle, and the quick-change feed box. British features include the large hollow spindle, design of the bearings, the gap bed and general massiveness of the build. The tailstock spindle also passes completely through the tailstock, giving a bearing of excellent length. The two designs have been produced after close study of the probable requirements of purchasers with a view to the evolution of machines which might be standardised and yet appeal to the large majority of possible customers who have to pay strict regard to considerations of price. In the 6½-in. lathe the 3-step cone pulley with back gear and two-speed countershaft gives 12 changes of spindle-speed, while the feed change-box gives 28 changes. An index plate of threads and feeds is placed on the feed box. The tumbler notches are arranged so that a full gear must be engaged. The maximum length between centres is 39 in., and the swing over saddle, 8 in. In the gap the lathe will swing work 20 in. in diameter.

The 8½-in. lathe, which we illustrate, has a length of bed of 9 ft. 2 in., and will take work between the centres of 5 ft. long. The swing in the gap is 21 in., and the width of gap in front of face plate, 9½ in. Over the saddle the swing is 10 in. The tailstock spindle has an adjustment of 9 in., the spindle being 2½ in. in diameter. The main spindle has a diameter at the front bearing of 3⅝ in. It is bored through with a 2 5/16-in. hole.

The single pulley drive to the headstock is fitted with a friction clutch operated by a wooden rod running the length of the machine above it, within easy reach of the operator. The geared head gives eight changes obtained with two levers on the cover. The gears are of chrome-nickel steel and run in an oil bath. The driving pulley is 11 in. in diameter and takes a 3½ in. belt, the horse-power required being from 5 to 6. With the pulley running at 240 r.p.m. the change gears give spindle speeds ranging between 14 r.p.m. and 345 r.p.m. The spindle runs in gun-metal bearings and is lubricated by ring oilers. The feed box gives 28 feed and screw-cutting changes; the feeds vary from 8 cuts per inch. to 112 cuts per inch. An index plate is provided on the feed box and also on the headstock. Metric or special pitches can be cut by the use of extra change gears at the end of the bed.

The saddle is fitted with a compound slide rest with micrometer collar reading to 1/1,000ths of an inch on the cross traverse screw. The tool post is a square turret capable of carrying four tools. Normally, the tools are of 1¼ in. by ¾ in. section. The apron provides double bearings for the principal shafts. The forward and reverse controls of the feed are effected at the apron by means of a small handle interlocked with the guide screw nut. The hand wheel for saddle traverse is on the left of the apron close to the work. All gears are fully encased and a guard protects the lead screw from cuttings. The traverse screw of the slide is also protected.

Messrs. John Holroyd and Co., Limited, Milnrow, near Rochdale, are also among the exhibitors of lathes. This firm is showing the 9 in. combination turret lathe illustrated in Fig. 76, Plate XXXVI, and besides this a 9½ in. universal relieving lathe for backing off milling cutters and parallel or taper hobs with straight or spiral grooves. Another tool shown is a 6½ in. test piece lathe using scroll formers, while three small capstans are also shown for bar work of 7/16 in., ¾ in. and 1¼ in. diameter, respectively. A bar turret lathe of up-to-date design is also to be seen at the firm's stand.

The 9 in. combination turret is a machine designed for heavy work. It has a single pulley drive with fast and loose pulley on the headstock. These are 14 in. in diameter and 4½ in. wide. The gear changes are controlled by three levers, 18 spindle speeds being obtainable varying from 9 r.p.m. to 378 r.p.m. The gear box encloses sliding gears and one friction and one positive clutch. All gears run in oil and the shafts have ring oiled bearings except in the case of the main bearings. The spindle is hollow, being bored out to 2⅜ in. The bearings are parallel and of phospher bronze, the front one having a length of 6½ in. by 4½ in. diameter. The spindle tail has a bell chuck for steadying bars. The saddle has large surfaces and is guided by the front shear only. Felt oiling pads under the saddle wipe the surfaces clear of dirt during traversing movements. The saddle runs close up to the headstock so as not to interfere with the turret slide. The length of traverse of the tool saddle is 36 in. The cross slide has a square revolving tool post taking four tools. Four automatic length stops are provided for the saddle, and four for the cross slide.

The feed box is controlled by three levers, one being for forward and reverse, and the others for the feed changes, which are six in number, ranging from 8 to 48 cuts per inch. The feed box drives a traverse shaft and also a chasing screw. A slipping clutch is embodied in the feed shaft to prevent damage to the gears. The change from sliding to surfacing is controlled by a plunger on the apron, on which is also a lever for engaging the power traverse arranged with an interlock which prevents the chasing gear being put in when the traverse is in and *vice versa*. The feeds are engaged at the apron by a falling worm box, the end thrust of the worm being taken on ball washers. All shafts in the apron have double bearings.

The turret slide also has felt oiling pads, and is guided by the front shear only. It has a travel of 36 in. The indexing plunger works in bushes, both being of tool steel hardened and ground. The slide can be locked to the head by a lever. One of the special features is the lever on the top of the saddle to the right of the turret. By means of this lever the turret can be slightly lifted off its face on to ball bearings so that it can be very easily revolved. This greatly eases the effort required in a day's work and at the same time preserves the turret seating. The lever acts also as a lock. The turret slide apron is double walled and a feed change plunger on it enables six additional feeds to be utilised, making 12 in all of from 20 to 200 cuts per inch. Quick power traverse can be utilised for the turret slide, engaged by a small lever above the hand-wheel to the right. This motion is derived from a shaft, at the back of the bed, cut with a quick thread in both directions. This shaft is belt-driven from the fast and loose pulley shaft, the small back shaft pulley being visible in Fig. 76 below the fast and loose pulleys. Trips are provided for the turret traverse, one or more of which can be used for each face. The automatic stop bar is the lowest shaft just above the suds tray and the trip plunger on the turret slide apron will be seen behind the hand wheel. Suds trays surround the legs of the machine and drain into a central tray carried on wheels. The central tray is arranged with a strainer and sump.

The greatest length of bar that can be worked is 30 in., and that can be chased 12 in. The largest finished size of bar work is 2½ in. The swing over the bed is 18 in. and over the tool saddle 12¾ in.

A very uncommon tool is to be seen at the stand of Messrs. A. A. Jones and Shipman, Limited, of Leicester, in the form of the Sundstrand stub lathe. This is an American machine developed by the Rockford Tool Company, of Rockford, Illinois, and for which Messrs. Jones and Shipman are sole agents. The tool is illustrated in quarter front and back views in Figs. 77 and 78, Plate XXXVI. It has been designed to secure great rigidity and entire freedom from vibration and chatter on maximum output. The height of centres over the tool slide is 4 in. and maximum length between centres 11 in. The bed is of box section heavily ribbed and the headstock is solid with it. The provision of the overhanging arm is another unusual feature, introduced to give the

maximum support to the tailstock, which, as will be seen in Fig. 77, is clamped to the arm and further held below by a stud fitted with a nut and collars. The combination of collars allows the tailstock to be rigidly held by the stud whatever the position of the overhanging arm. The latter is cut with rack teeth and can be adjusted over a range of positions. The overhanging arm, which has a diameter of 3¼ in., causes the machine to resemble in this feature the modern horizontal milling machine, but in this case instead of the cutter being mounted on the spindle the work is carried on this part by suitable chucks, which may be arranged for air operation or otherwise as preferred.

The Sundstrand stub lathe is driven by electric motor housed in the base under the headstock, where it is mounted on a pivoted plate, with adjustment to obtain the necessary belt tension. The single constant-speed pulley at the back of the machine is shown in Fig. 78. It is fitted with a friction clutch mounted on roller bearings, controlled by a lever reaching over the headstock to the front of the machine. The main shaft drives change wheels on the front of the machine, whence the drive is transmitted to the spindle through bronze worm gearing. The worm is fitted with a ball thrust bearing. The standard reduction of the worm gear is 8 to 1, while four sets of change wheels give eight spindle speeds of 30, 40, 50, 65, 85, 110, 145, and 192 r.p.m. In certain cases, higher spindle speeds are advisable, and the 8 : 1 reduction is then changed to one of 3 : 1.

The spindle is of crucible steel, and runs in phosphor-bronze taper bearings. The front bearing is 6 in. long, and tapers from 4¼ in. to 3¼ in. Take-up for wear is arranged by means of a single nut at the rear of the spindle. The spindle nose is 4 in. in diameter, and cut with two threads per inch.

Both front and rear tool saddles are provided, the front one being arranged with automatic longitudinal traverse and hand cross traverse, and the rear one with cross traverse only. The front saddle is 18 in. long and works on a horizontal slide, having very large bearing surfaces. The vertical face is 8 in. deep and the angular face of the top vee 4 in. wide. There is an angular gib at the bottom of the saddle for adjustment. The saddle traverse is 8 in. The front tool slide has stop screws for adjusting depth of cut, and several tools can be clamped to the tool block at once. An adjustable tripping dog is arranged in a slot on the saddle and can be set as required to trip a lever which causes the feed worm to disengage from the worm wheel of the feed drive. This trip is very accurate in action. The feed drive is taken from the main spindle by sprocket and chain to a shaft on which is mounted a worm driving a large worm wheel. The hardened steel worm is immersed in oil. To engage the feed, the worm is lifted into engagement with the worm wheel by a lever at the front of the machine, close to the saddle. The worm wheel is keyed to a pinion shaft driving the carriage by a rack. On the pinion shaft is a 15½-in. hand wheel for hand feed to the carriage and rear slide. Change gears give eight feeds for the saddle ranging from 0·005-in. to 0·046-in. per revolution of spindle.

The rear saddle is used for facing and parting. It has a travel of 4 in. It is operated simultaneously with the front saddle, but change gears, whose location will be noted in Fig. 78, at the back of the machine, provide for a range of feeds to suit different jobs. By ten changes of gears the cross traverse of the rear slide can be made to vary between $\frac{1}{16}$ in. to 4 in. for a longitudinal movement of the front saddle of from 1 in. to 8 in. The tailstock spindle diameter is 2⅜ in., the maximum travel of the spindle being 6 in. The spindle bearing is split and held in position with screws, which may be adjusted for wear.

The power taken by the machine varies with the class of work; 5 h.p. suffices for some jobs, while 15 h.p. would be recommended for regular production work on others. The machine lends itself well to multi-cutting arrangements both for the back and front slides, while the overhanging arm may also be utilised to carry additional tools. It is not possible here to go into the question of tooling, but we may say the possibilities of the machine are very large from a tool that is in reality a very simple one.

A single-purpose machine coming within the class of lathes is the pulley-turning lathe illustrated in Fig. 79, Plate XXXVII, and exhibited by Messrs. Ward, Haggas and Smith, of Keighley. This machine is very simple and straightforward in design, as will be gathered from our illustration. It is designed to turn pulleys in the shortest possible time, running up to the limit of high-speed tool steel. The bed consists of a rectangular box-shaped casting on one side of which, and cast integral with it, is a headstock, and on the other a tailstock. The main drive, as will be seen, is by cone belt pulley and worm reduction gear to the spindle. The worm gear runs in oil, and the thrust is taken on heavy ball-thrust bearings. The spindle is 5 in. in diameter and runs in a bearing 16 in. long. The spindle thrust is taken by ball-thrust washers. The spindle is fitted with a self-adjusting driving plate.

The top of the central portion of the bed, between the head and tail-stock, is solid, and on either side has a T-slotted surface. Two cross-slides are mounted on these, one in front and one at the rear. They can be adjusted independently towards or away from the work by screws, and clamped. The cross-slides carry saddles with square tool turrets mounted on the upper slide, capable of being rotated and locked in four positions. The saddles have each three independent feeds and reverse, while automatic trips are arranged to the feed in both directions. All gears in the feed box are of steel.

The machine is illustrated in Fig. 79 arranged to finish the pulley face to a radius. A carrier is bolted to the face of the cross-slide, and in this is fixed a radius plate. A roller on a lug under the cross-traverse tool slide moves in the slot in this plate, and as the saddle is fed across, the pulley face causes the tool to repeat the curve of the template on the pulley. The speeds are arranged to give approximately a cutting speed of 40 ft. per minute on a regular gradation of pulley diameters. The machine is driven by a 5 h.p. motor.

Drilling Machines.

In our last issue we dealt with a number of drilling machines exhibited by various firms, including several of the high-speed ball-bearing type of sensitive drills. In this article we propose to deal mainly with the larger classes of machines. Before passing to these, however, we wish to refer to the small ball-bearing multiple sensitive illustrated in Fig. 80, Plate XXXVII. This is made by Messrs. Smith and Coventry, Limited, of Manchester, and can be had as a single spindle tool, or 2 or 3, and up to 6-spindle multiples. The machine shown is fitted with a central head of the plain type. The right-hand head has automatic feed, while that on the left has reduction gear for facing, counter boring and tapping. The spindle and idler pulleys run in ball bearings. The length of feed is 5 in. and the distance from spindle centre to face of column is 7½ in. The quill is carried in a sliding head. At the upper end is an automatic take-up to eliminate all end play of the spindle. The greater part of the weight of the quill and spindle is balanced. The spindle is belt-driven from a countershaft at the back of the column. Each head has a 3-step pulley on the countershaft, while the spindle cone has two steps; the belt may be used to drive any combination, by means of a patented idler gear which includes a pulley on a throw-over arm, by which correct belt vertical alignment is obtained. The correct tension is obtained by a lever sliding the idlers away from the head. All belt shifting can be done from the front of the machine. The geared spindle gives a reduction on normal spindle speeds of 4 to 1, these gears running in ball bearings. The automatic feed is taken from the spindle belt pulley by chain belt to a vertical feed shaft extending to the feed box on the sliding head. The automatic feed is engaged by twisting the cross-axle hand lever on its own axis; this movement engages a coil friction clutch in the head, the resistance of the drill assisting to maintain the clutch in engagement. A slight resistance offered to the rotation of the hand lever on the head causes the clutch to disengage. An automatic trip is available on the head. Three feed changes are operated by a sliding thumb piece on the top of the feed box. The standard spacing of the heads in multiple machines is 9 in.

Turning now to heavier machines the most conspicuous exhibit of this class will be found to be that of Messrs. William Asquith (1920), Limited, of Halifax. One of this firm's machines is illustrated in Fig. 81, Plate XXXVII. This is a 7-ft. radial for medium-duty drilling, boring and tapping, fitted with separate spindles for drilling and tapping. The gear box is mounted at the end of the arm, the total available spindle speeds being 18. The main drive includes three pulleys, two fast and one loose. The fast pulleys give opposite directions to the vertical shaft. With gearing on the saddle one pulley gives correct rotation for drilling in single gear. The other gives the correct sense for double gear, and for reversing after tapping the spindle is thrown over to single gear. This movement reverses and at the same time gives a quick speed for backing out. In a universal radial machine shown, of somewhat similar type, the arm is arranged to swivel through 180 deg. while the saddle swivels through 85 deg. making the drill available for holes in any direction.

Another fine example of the radial class of machines is shown in Fig. 82, Plate XXXVIII. This is a new model by Messrs. William Asquith, of 6-ft. heavy-duty central-thrust radial drill. As may be gathered from the illustration this machine is intended for the heaviest class of work. The diameter of the spindle at the driving part is 3¼ in., the spindle end being bored to Morse taper No. 5. With a maximum radius of 6 ft. the spindle can be run into a minimum radius of 2 ft. 1 in. The maximum height from the spindle nose to base is 6 ft. 1 in. and the minimum 3 ft. 3 in. The vertical adjustment of the arm is 2 ft. 10 in., and the hand and self-acting feed for the spindle is 1 ft. 6 in. The feeds are six in number. The base plate has a length of 12 ft. 7 in. and width of 4 ft. 6 in. The machine is driven by a variable-speed motor with shunt regulator control from the saddle, all other controls being centralised here as well. The drive includes single, double and treble gear changes obtained from the saddle and giving a continuous range of speed variation, from a maximum of 400 r.p.m. in single gear, to a minimum of 8 r.p.m. in treble gear. The motor is carried on a tail bracket on the arm sleeve, making a very well-balanced and neat design. The main sleeve is mounted on a large column. Power elevating of the arm is secured by means of a separate motor mounted on the top of the column. Hand or power radial movement is obtained from the saddle through a vertical spindle and pinion at the column engaging with a spur on the column base. The advantages of the central thrust type of arm and saddle are so apparent for heavy work that we need not enlarge upon them here. The model is made in sizes from 5 ft. up to 10 ft. and over.

The vertical drilling machine represented in Fig. 83 is another new model of Messrs. Asquith's. This is a 24-in. drill, admitting work of a diameter of 48 in., the circular revolving table having a diameter of 3 ft. 6 in. and a traverse of 2 ft. 1 in. The table is locked for both motions by a single lever to be seen at the near corner of the saddle in Fig. 83. The revolving and longitudinal motions enable every part of the table to be brought under the spindle. No table elevating gear is provided and the support is therefore exceptionally rigid, the machine being intended for high speeds and heavy duty. The spindle is six-splined and has a diameter of 2⅜ in. at the driving part. Eighteen spindle speeds are obtained from a gear box on the side of the column, with two levers, the main drive being by motor on a bracket at the back of the base to the gear box, by silent chain and sprockets. The gear box gives nine speeds, which are doubled by back gear in the head. The spindle speeds range from 27 r.p.m. to 405 r.p.m. There are four rates of feed from 35 to 120 cuts per inch. The spindle feed is 15 in., hand feed being available as well as power. Changing speeds, stopping, starting or reversing, can all be controlled from one position at the side of the machine. Quick vertical hand adjustment of the spindle is by

the star wheel, the auto-feed being engaged by the small cross handle in front of this. Feed changes are obtained by the small handle with dial at the side of the head. The speed changes are worked by two pendent levers, one of which is shown in the hand of the operator. These couple by rods to the gear box at the back. The back gear lever on the head is the one slanting downwards close to the feed box. The short-crank lever under the head coupled by rod to the gear box at the back controls the starting, stopping, and reversing operations by means of clutches. The column and head of this machine are also utilised by Messrs. Asquith in a multiple pattern machine.

We have on previous occasions illustrated Messrs. William Asquith's design of a girder drilling machine. The latest development of this type is shown in Fig. 84, and introduces several improvements, notably a new feed lock, and still further centralised control. The machine exhibited is a 6-ft radial, but 10-ft. and 12-ft. radius models are also made. As regards construction the chief features are the central thrust arm, and the motor mounted on a bracket on the tail of the arm and serving, to some extent, to balance it. A lighter type is made with the saddle on the front face of the arm, after the usual practice in radial machines. The drill is usually supplied without a base plate as it is intended for placing as convenient on a large floor plate, or can be arranged in gangs for long girder work. The height from spindle nose to bottom of pillar with spindle in its highest position is 4 ft. 3 ins. The head can be run into the column close enough to give a minimum drilling radius of 1 ft. 9 ins. The feeds are three in number and the feed traverse, either hand or self-acting, is 15 ins. In the machine exhibited the drive from the motor is to a four-speed gear box. The patent feed lock fitted to the drill enables the arm to be locked against radial movement, the head to be locked on the arm and the power feed to be started, with a single lever movement at the head. The lever by which this is accomplished is the one projecting diagonally upwards, seen behind the two hand wheels on the head in Fig. 84. When the drill point has been correctly located this single lever operates the locks and throws in the feed so that the risks from possible carelessness on the part of the operator are greatly reduced, with a resulting reduction of drill breakages. At the same time, this single movement tends to increased output since the man has one, instead of two or three operations to attend to. The combination absolutely eliminates all risk of the operator working at a high speed omitting to lock the arm or saddle before getting the drill to work.

A 4-ft. 6-in. radial by Messrs. James Archdale and Co., Limited, is illustrated in Fig. 85. This machine is somewhat similar to the radial drills exhibited by this firm in 1920, but embodies several modifications. Among these is the more extended use of ball bearings. This, in fact, is a marked tendency throughout machine tool design. The drive in the 4-ft. 6-in. radial now under notice is by belt to a single-speed pulley at the base, whence it is transferred to gears at the top of the column. Except for the belt thrower and the arm elevating gear, all controls are on the saddle. The elevating gear is controlled by a lever at the base of the sleeve working a vertical rod which locks and unlocks the arm and throws in the elevating motion gears transmitting the drive to the vertical screw hanging from the gear box. This combination prevents engaging the elevating motion while the arm is locked or locking the arm while the gear is engaged. Among the recent modifications may be mentioned a third rail on the arm to give additional steadiness to the saddle. The clutch lever and speed levers are interlocked so that the gears cannot be changed under load. Improved multi-disc clutches have been introduced for the spindle control. The spindle is of the splined type, this being another instance in which high-class motor car engineering has been applied with advantage to machine tool design of late years. The gear box on the saddle gives nine speeds, which, with back gear for the spindle, enable a range of 18 spindle speeds to be obtained from 27 r.p.m. to 580 r.p.m. The spindle has a vertical feed of 15 in. at four rates of between 32 revolutions per inch and 120 revolutions per inch. The machine has a base plate, the working surface of which measures 4 ft. 9 in. by 3 ft. On this is a removable work table 32 in. by 27 in.

Fig. 86, Plate XXXVIII, illustrates a sensitive radial drilling machine of the geared type, by Messrs. James Archdale and Co., Limited. The single belt pulley at the base of the column drives a horizontal shaft transmitting to a vertical spindle running to the main gear box at the top of the column. The sleeve has ball and roller bearings. At the end of the arm a stay is provided connecting with the bed. This stay is supported on roller and ball journal bearings on a segment which extends to the rear of the bed, so that it may perform its duty with the spindles working over most of the bed. A clamp is brought into action as soon as the thrust is taken by the drill. Even with the saddle at the end of the arm the effort to move the arm and stay is very small. The saddle is carried on rollers on a square edge. The saddle carries a lever by which the arm is locked on the column, this being effected by the horizontal bar below the arm and a lock at the column base. The saddle can also be locked to the arm. The maximum radius at which the drilling spindle will work is 4 ft. 6 in., and for the tapping spindle 4 ft. 1 in. The vertical feed of the spindle is 6 in. and the vertical adjustment of the spindle head on the saddle, 8 in. The horizontal traverse of the saddle is 2 ft. 10 in.

The gear box at the head of the column gives nine spindle speeds of from 126 to 1,440 r.p.m. The spindle runs in a quill and has roller and ball thrust bearings, and is counterbalanced. It is driven from the backshaft by helical gearing. The tapping or studding spindle is fitted with reverse, operated by lever. It runs at one-quarter the spindle speed and reverses at 1·5 times the tapping speed. One turn of the star wheel locates the tapping spindle directly over the hole just drilled. The necessary slipping device for tapping is embodied in the saddle, and an external tapper is unnecessary. For backing out a large Ferodo-lined clutch is brought into action. The automatic feeds are three, namely, 50, 95 and 180 revs. per inch.

The next machine we illustrate is a special gang drill for motor car front axles, for the swivel pin and spring pad holes. As will be gathered from Fig. 87, the two outer heads swivel on the slide, while the two inner heads are provided with five spindle multi-heads. The main drive is by belt and pulley to the cross rail, with change wheels. The spindles have self-acting feed of 9 in. and four rates of feed are arranged for. The machine will drill four 1¼-inch holes, and is tested by drilling in steel four ¾-in. holes at a penetration of 5½ in. per minute. The two inner spindles can be set as close as 10 in. apart; the distance between an outer and the nearest inner spindle can be made as little as 7 in., while the greatest spread between two outer is 54 in. The size of the table is 15 in. by 69 in. It is carried on vertical slides on the two columns and is supported by two telescopic elevating screws worked by spur gear and a single handwheel. The main motion shafts are fitted with ball or roller bearings. The spindle quills are fitted with ball and roller bearings. The spindles are driven by helical gearing, each having a friction clutch, so that any can be disengaged when necessary. Each head is provided with trips, and the spindles may be fed simultaneously or independently. They are not engaged simultaneously. Quick change speed and feed boxes provide suitable speeds for reaming.

Another gang drill shown by Messrs. James Archdale and Co. is illustrated in Fig. 88. This is a three-spindle heavy-duty vertical drilling machine capable of drilling up to 3-in. holes, the distance from the centre of spindle to column being 10 in. This machine is a multiple-unit tool, each drill being similar to but independent of the others except as regards base and table. A single unit forms one of Messrs. Archdale's standard single-spindle machines, while in the multiple form it is to be had in either two-, three- or four-spindle machines. In these standard forms the spindles are spaced 26½ in. apart. For the three-spindle machine the table top is 15 in. by 69 in., the length of course differing in other models. The table, it may be pointed out, is similar to that of the preceding machine, having two elevating telescopic screws worked by one handwheel and gearing. The table can be locked to the columns.

The drill is for heavy work, requiring 6½ h.p. per head to drive it at full capacity. Each head has a separate belt pulley. All shafts run on ball bearings and a feature of the design is the use of spiral bevels both for the driving shaft and the spindle drive; these result in a very silent machine. The spindle is of liberal dimensions, being 1¾ in. in diameter below the splines, and 2⅛ in. in the quill. The quill diameter is 4½ in. It has ball journal and thrust bearings. The spindle is cut with six splines, ensuring freedom from failure of feathers. The range of spindle speeds is 24, obtained by change gears, sets being provided according to requirements. The lowest and highest speeds are 66 r.p.m. and 265 r.p.m. The vertical self-acting feed is 10 in., four rates being provided, obtained by a single lever on the side of the head. They range from 32 revolutions per inch to 130 revolutions per inch. The automatic feed is engaged by means of a friction clutch. An automatic depth drilling device is included in the design, a large graduated disc facilitating accurate setting. This enables a number of heads to be attended to by one operator with perfect safety, so that the machine is capable of heavy work at low cost. The whole has been developed with a view to producing a simple and robust machine, as many parts as possible being eliminated to ensure immunity from breakdown, and the rest made as substantial as consistent with good design, for the same reason. The machine can be utilised for multiple drill heads, and can be used for rolling the bore of cylinders for automobile engines, &c.

A drill shown by Messrs. Crossley and Co., St. Mary's Gate, Manchester, is a radial of 5 ft. 3 in. It is a high-speed machine of the single-pulley and gear-box type as will be seen from Fig. 89, Plate XXXVIII. The gear box, by means of two levers, gives six changes of spindle speed, which can be used with or without back gear on the saddle, allowing a range of 12 changes of from 46 r.p.m. to 400 r.p.m. The arm is solid with a long sleeve, which is supported on the column by ball and roller bearings, and can swing the complete 360 deg. The spindle has a diameter of 2½ in. at the driving part and 2⅜ in. in the quill. It is fitted with ball thrust bearings and driven through a friction clutch, and is started, stopped and reversed by a lever on the saddle. The spindle is counter-balanced and has a vertical feed of 15 in., four rates of automatic feed being provided, namely, 40, 58, 85 and 135 revolutions per inch. Quick hand and fine hand motions are furnished, and also an automatic trip. After tapping, the tap can be run out at 3·3 to 1 by putting in the single gear. The traverse of the saddle on the arm is by rack and pinion on the saddle. The minimum radius at which the drill will operate is 1 ft. 4 in. The maximum distance from spindle work table is 2 ft. 2 in. and the minimum 11 in.

Shaping Machines.

A 30-in. stroke double-geared shaping machine shown by the Selson Engineering Company, Limited, is illustrated in Figs. 90–98, Plate XXXIX, and Figs. 99–107, page 360. From the photograph given in Fig. 95 this will be seen to be a very neat machine. The drive is by fast and loose pulley on the left-hand of the machine, through a shaft carried at the back of the body to a gear-box on the right side shown in our illustrations, Figs. 91 and 95. Details of the drive are illustrated in Figs. 100 and 101. An alternative drive by four-step cone pulley is illustrated in Fig. 99. In this case the cone pulley is mounted without gear-box on the first motion shaft of the ram drive. In the geared model the driving pulley is 14 in. in diameter and runs at 300 r.p.m. The gear-box gives four speeds, with two levers shown in plan in Fig. 107, and in elevation Fig. 106, which drawing shows the sliders for the gears on the first and third shafts, the gears on the intermediate shaft being fixed. The levers have two operating positions and neutral, and by means of sliding back gearing the changes can be increased to eight. These give a range of eight changes of strokes per minute. The back gear arrangement will be

understood by reference to Fig. 100, where it will be seen that two gears sliding on the shaft fitted with the hand wheel can drive the bull wheel direct through a small spur, or if moved to the other side of the body can be made to engage with a much larger spur on the same shaft as the former. The feed box shafts run in bronze bushes oiled from oil wells shown in Figs. 104 and 105. The gears run in oil. The pulley shaft and the intermediate spur shafts in the body are provided with ring-oiled bearings. Details of these ring oilers are given in Figs. 102 and 103. Details of the feed motion and stroke adjustment gear are shown in Figs. 93 and 94, a stroke indicator shown in Fig. 92 being fitted just above the stroke-adjusting handle. The bull ring is carried by a large hollow shank through which passes a spindle gearing by bevels with a screw which adjusts the distance of the crank-pin in a slide revolving with the bull ring. The stroke-adjusting spindle is screwed and is surrounded by an internally screwed sleeve or nut in which a groove is turned. In this groove works a smaller roller on the end of the pointer lever. As the adjusting spindle is turned the sleeve moves in or out and the groove and roller cause the indicator to travel over the scale on the top of the box. This will be followed by reference to Figs. 92 and 93. A great advantage arises from the indicator being a stationary one.

The traversing feed is by means of a small slotted disc crank, graduated as shown in Fig. 93. This is revolved by means of a spur on the end of the bull wheel shank. This spur wheel is in mesh with a second underneath it in the feed-box carried by the hollow shank of the bull wheel. This spur can either revolve freely on the shank, or be locked by key to it, the key being operated by a spring plunger passing through the centre of the shank and worked by a lever below the box in a manner which is clearly seen in Fig. 94.

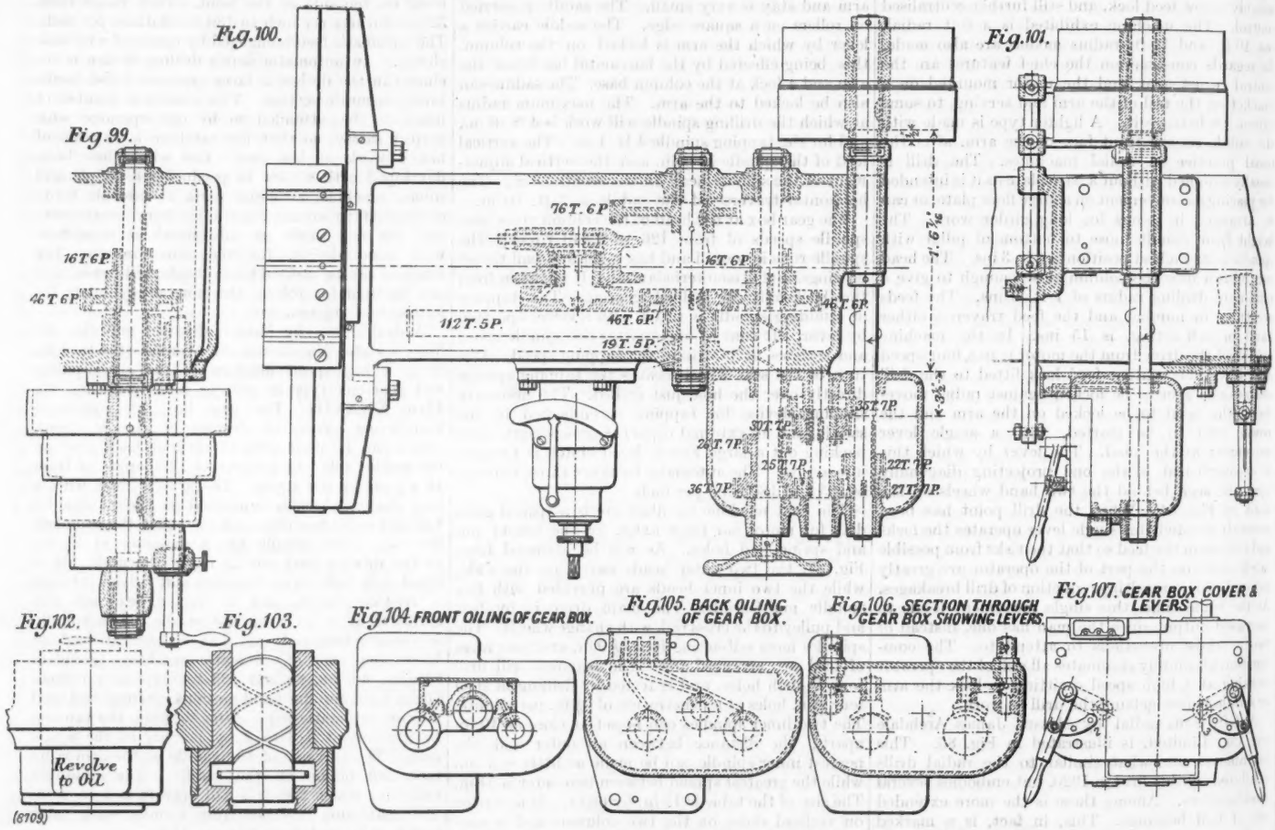
The ram is adjusted by means of a large hand wheel on the top, and rack and pinion. Combined with this is a locking lever, the block of which clamps on to a serrated surface on the upper side of the ram. The main driving link is coupled to the ram by a connecting link, giving a draw stroke. The tool head swivels, the circular edge being graduated. Details of the head are given in Figs. 96 to 98, Plate XXXIX. The box has a vertical adjustment of 9 in. on the slide. The vertical hand feed is by an inverted hand wheel and bevels, giving a much more convenient position for the wheel than is usual on a large machine, and enabling the operator to observe the tool point closely. The collar of the feed screw is graduated.

The table is 17 in. by 30 in. across the top face and the sides, 17½ in. deep, are both planed with T-slots. The table traverse on the cross slide is 31½ in. and the vertical traverse of the cross slide is 15 in. The table can be raised to within 4 in. of the tool-box, while the maximum distance available is 19 in. The automatic and hand cross traverse motions are by the upper of the two shafts on the cross slide (Fig. 90). The lower shaft is for the vertical traverse, by hand only, the shaft working a nut on the elevating screw. The cross traverse shaft has a graduated collar. A strong double brace support is provided for the table, with rollers running on a guide extending across the front of the base far enough to give support to the table when in its extreme positions of cross traverse. The table is fitted with a large swivelling vice, graduated on the plate edge, and giving a maximum opening between the jaws of 1 ft. 2 in. Throughout the machine the slides are fitted with adjustable taper fitting strips, while felt wipers protect all oiled moving surfaces. The body is hollow under the ram to admit shafts up to 4 in. diam. for key seating.

The Butler Machine Tool Company, Limited, Halifax, are well-known makers of shaping machines, and their exhibit includes five machines of this class. Four of these are single-head crank shapers, the fifth being a double-headed machine. The latter and the largest single-head machine are illustrated in Figs. 108 and 109, page 361.

The double traversing head shaper, illustrated in Fig. 108, has two heads with rams having a maximum stroke of 26 in., the heads being arranged to traverse on a long rectangular body, fitted with slides on the top, for the heads, and on the front for two box-work tables. The body is 12 ft. long, 28 in. wide, and 32¾ in. deep. The centres of the heads can be approached to as close as 1 ft. 6 in., or spread as far apart as 8 ft. 3 in. The tables are each 27 in. long, 20 in. wide, and 20 in. deep. The machine is driven by two independent direct-current motors of 15 brake horse-power, made by Electromotors, Limited, Openshaw, Manchester. These run at 1,050 r.p.m. They are carried on brackets at the back of the machine, attached to the body, and drive the heads through friction clutches and gear-boxes. Two horizontal shafts transmit the drive to the heads whatever their position on the bed. The clutch-operating gear includes a brake by which the ram can be arrested in any position while the motor is allowed to continue running. The clutches are to be seen at the ends of the machine, with starting and brake handles on the outside. The heads, being driven by independent motors, can be operated as desired regardless of one another, each having available the choice of eight changes of speed. The boxes give four changes and these can be doubled by gearing. The ram motion is of the Whitworth quick-return type, combined with helical wheel drive from the shaft. The ratio of quick return is 2½ to 1 for all strokes. With this form of motion the tool speed is low at the moment of entering and leaving the cut, tending to accuracy of work. The headstocks are furnished with quick power traverse, so that the operator is relieved of exertion and the capacity of the machine is considerably enhanced. The choice of traverse feeds for the head is the same as for the speed, viz., eight. The quick traverse is controlled in each case by an extensible lever close to either head so that whatever the setting of the ram the lever may be within reach.

The tool boxes swivel and are arranged with arc slot and worm quadrant. The vertical feed screw is operated by a reciprocating quadrant



FIGS. 99 TO 107. DETAILS OF 30-IN. SHAPING MACHINE; THE SELSON ENGINEERING COMPANY, LIMITED.

SHAPING MACHINES AT THE MACHINE TOOL EXHIBITION.

CONSTRUCTED BY THE BUTLER MACHINE TOOL COMPANY, LIMITED, HALIFAX.

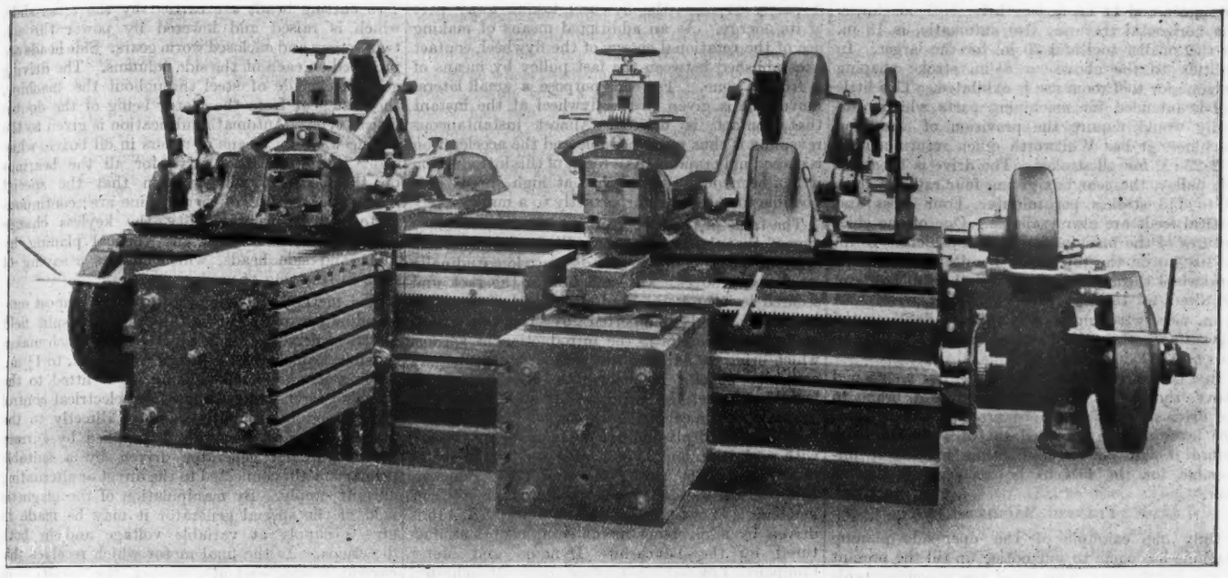


FIG. 108. 26-IN. DOUBLE TRAVERSING HEAD SHAPING MACHINE.

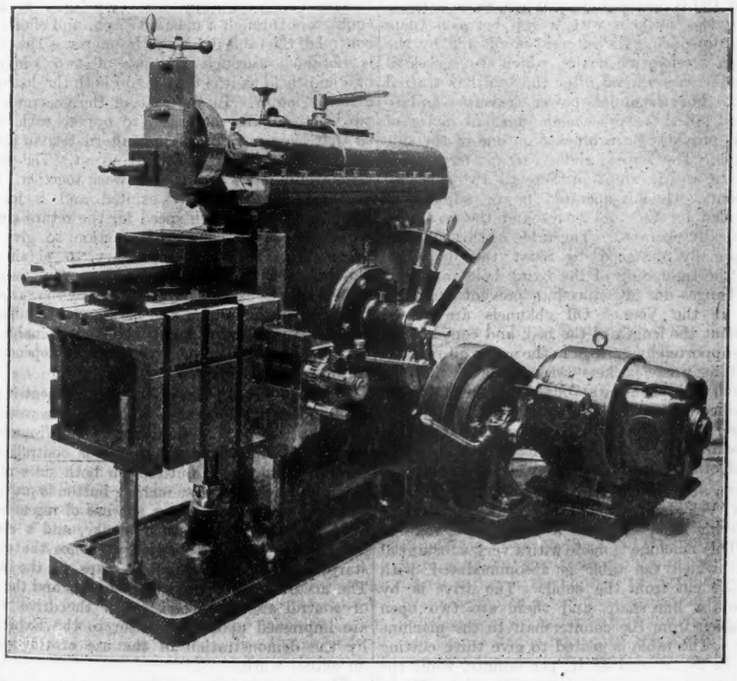


FIG. 109. 22-IN. CRANK SHAPING MACHINE.

and connecting rod. The drive is obtained by lowering the quadrant which is hung on the ram into contact with the stationary slide. Friction between the surfaces rocks the quadrant and this action is transmitted to pawl gear on the head. This arrangement is self adjusting to the length of stroke, and is capable of instant release. The traverse feed is by pawl and ratchet off the crank-shafts on the head. A slotted disc crank provides for variation of traverse. Fine hand traverse is also provided, the ratchet handle for this being balanced so as always to return to the vertical position. The feed is reversed by turning round the pawl in its sleeve so that it catches the ratchet teeth when moving in the opposite direction.

The two tables are mounted on saddles capable of being traversed along the front of the body by a rack and pinions. The latter are operated by spanners. The tables can be elevated by screws housed in vertical slides in the saddles, all projecting screw ends thus being avoided. The tables are locked on the saddles by long bolts passing through to the front. Two faces, the top and one side, are finished with Tee slots on each table. A strong vice forms part of the equipment with gripping screw in tension.

The 22-in. stroke single head shaper is illustrated in Fig. 109. It is driven by a direct current electric motor of 7 h.p. running at 1,100 r.p.m. The main drive is fitted with a friction clutch controlled by a handle at the side of the machine. This also applies a brake and the tool can therefore be stopped when required without stopping the motor. The ram can be adjusted whilst running. The drive is by raw hide pinion on the motor shaft meshing with machine-cut spur. The machine is fitted with a self-contained change speed gear box inside the body, giving 6, 9, 13, 18, 28, 38, 55 and 81 strokes per minute. There are two levers for the gear box and one for back or double gear. The work table has a rectangular Tee slotted top, and slots, both vertical and horizontal, are also cut in the vertical finished side faces so that a great variety of work can be readily fixed to it. The table has automatic traverse and is carried by a cross slide having power elevating motion or vertical feed. The former movement extends for 25 in. and the latter, extending over 14 in., is effected by a friction drive of the type described above in connection with the double head machine, with rocking quadrant. The usual pawl motion is fitted to the cross traverse. The tool-box tool holder and vertical slide are of forged steel. The ram slides are hardened and ground.

The crank is of the closed type and is balanced, eliminating vibration and giving smoothness of running. The stroke may be changed while the machine is in motion. The upper part of the body gives a clear way for the ends of shafts, etc., $3\frac{1}{2}$ in. in diameter, when the machine is used for key-way cutting. The table in its lowest position will allow of work of a height of 14 in. under the tool box. The latter has a vertical adjustment of $7\frac{1}{2}$ in. and swivels to either side. The work vice is fitted on a swivel base which has jaws 12-in. wide by $2\frac{3}{4}$ in. deep, and a maximum opening of 14 in. The vice is arranged with the clamping screw in tension and not in compression, the thrust being taken on a steel collar which relieves the frame from strain. We may add that felt wipers are fitted to all slides.

The two other standard machines shown by the Butler Machine Tool Company are 12 in. and 18 in. crank shapers similar to the above but belt driven

on to a constant speed fast and loose pulley set, the internal gear-box giving six changes for the smaller tool and eight for the larger. The belt-shifting gear embraces a safety lock and brake by which the ram can be arrested in any desired position. The vertical traverse of the table is automatic and 12 in. in length for both machines. The horizontal traverse, also automatic, is 18 in. for the smaller tool and 20 in. for the larger. In addition to the above an 8½-in. stroke shaping machine for tool room use is exhibited. This little tool is intended for machining parts which ordinarily would require the provision of a milling machine. It has Whitworth quick return motion of 2·25 : 1, for all strokes. The drive is by single belt pulley, the gear box giving four rates of from 48 to 113 strokes per minute. Four cross and vertical feeds are also available. One of the chief features of the machine is its table which is 10 in. by 10½ in. on the top and 7 in. deep. The table can swivel through 180 deg. and the top face can be tilted to 15 deg. The tool also swivels. A 4½-in. vice swivelling on a base is available on the top surface, while there is a second vice with 6 in. jaws on the side face of the table.

In the belt-driven machines, as mentioned above, the belt-shifting lever applies a brake to the drive so that it can be arrested as required. The lever has to be lifted out of a slotted plate before it can be operated, thus making it impossible for the belt to be accidentally thrown over.

PLANING MACHINES.

Only one example of the open-side planing machine has come to our notice up till the present at the Exhibition. This is of the travelling table type associated with the name of Messrs. Ward, Haggas and Smith. Messrs. Geo. Richards and Co., Limited, of Broadheath, had intended showing one of their chain-driven travelling tool-head planers, but the firm finally decided to exclude it in favour of other machines.

The Ward, Haggas and Smith model is now well known. The machine exhibited on this occasion is substantially similar to that shown at the Exhibition of 1920, and described and illustrated then in our columns (ENGINEERING, vol. cx., page 333). The model we illustrated was driven by single-belt pulley and clutch. The present machine is motor-driven, with enclosed Coventry chain. The travelling work table has a length of 46 in. and width of 18 in., the tool box having a horizontal traverse on the arm of 22 in. The tool has a vertical adjustment on the side of 6 in. The table, which has six changes of speed, is operated by crank. It runs on V guides and is held down by gibs under the guides. Power movement is available for the arm and the horizontal, vertical or angular feeds to the tool are either by hand or power.

An interesting example of modern planing machine design is afforded by the exhibit of one of the range of the Bateman high-speed machines made by Messrs. Ward, Haggas and Smith, of Eastwood Works, Keighley. This machine is shown in Fig. 110 on Plate XL. It is driven by a variable speed motor which runs continuously in the same direction. The return speed of 190 ft. per minute is constant no matter what variations of cutting speed are used. Actually the cutting speed is varied by the use of a simple type of regulator control for the motor made by the Igranic Electric Co., Ltd., which is operated by turning an index handle over a disc graduated to read in actual feet per minute. The operator can, therefore, easily set the working of the tool to suit the particular class of work it is momentarily engaged on. Variation of the cutting speed between 20 ft. and 60 ft. per minute is thus possible.

The mere raising of the speed of cutting does not necessarily make for increased economy, because as the speed is increased, acceleration and retardation effects at the beginning and end of the cutting stroke continuously increase. This means that time is only saved at the middle of the stroke and is lost at the ends. To overcome this disadvantage of high speed working the Bateman design has incorporated in it the use of a flywheel drive. This works on the principle of restoring energy during the stroke and releasing it at the beginning and end of the stroke, so as to avoid making heavy demands upon the motor at these periods. It is fitted at both sides of the machine, and consists of a heavy flywheel as a loose pulley and a simple type of fast one. The flywheel is wider than the fast pulley, and when the belt is thrown on to this it partly overlaps the flywheel, taking away part of its energy. As an additional means of making use of the rotational energy of the flywheel, contact is established between the fast pulley by means of a friction cone. For this purpose a small lateral movement is given to the flywheel at the instant that contact is desired. Almost instantaneous reversing is thus made possible and the acceleration is exceedingly rapid. As a result of this introduction it has been demonstated that at high speeds it is possible to cut and return exactly to a mark.

The table of the planer differs from the ordinary type in that the rack is not rigidly fixed to the table but is free to slide for a short distance longitudinally in planed grooves. On each side of the rack and secured to it by a crosshead at the end of the table are buffer rods supported by brackets. This arrangement facilitates the introduction of springs which bring the table to rest without the commonly excessive shock. Adjustment of the springs is possible to meet the requirements when unusually heavy loads are carried on the table.

A high-speed planing machine capable of dealing with work 16 ft. long by 4 ft. wide and 4 ft. in height is shown by The Butler Machine Tool Company, Limited, of Victoria Iron Works, Halifax. This machine is shown in Fig. 111 on Plate XL. It is driven by a reversing motor equipment manufactured by the Lancashire Dynamo and Motor Company, Limited, of Trafford Park, Manchester. The motor is of 24 b.h.p. and runs at speeds between 575 and 1,150 r.p.m. This gives cutting speeds of from 20 to 75 ft. per minute and return speeds of 55 to 150 ft. per minute. When work is being done on two surfaces with a gap between them speeding up during the interval is effected by the use of an accelerating device, which also serves to give an increased speed after the tool has started the cut. For the quick power traverses and to raise and lower the cross slide a small motor of 4 h.p. is provided on a bracket on one of the side standards. The cross slide carries two main tool boxes, and in addition there are two side tool equipments. Quickly-operated power adjustment is provided for the tool boxes and the feeds are mechanically operated. The table of this machine was specially designed to resist the deflection due to the tightening of the fixing bolts, and side thrust flanges are introduced to prevent the table lifting at the Vees. Oil channels are placed throughout the length of the bed, and coned lubricators supported by springs in the many oil recesses as well as waste pockets serve to deal with the oil. Much more than the standard thickness of metal is provided above the Tee grooves to permit the replaning of the table. All the gears except the rack members have single helical teeth in order that smoothness and silence of working is ensured.

Messrs. John Stirk and Sons, Limited, Halifax, show a Veloplane which takes work 36 in. wide and 30 in. high, and has a length of stroke of 6 ft. This machine is made with a very substantial bed on which the table is accommodated with Vee ways cut from the solid. The drive is by belt from a line shaft, and there are two open belts taken from the countershaft to the machine pulleys. The table is geared to give three cutting speeds of 24, 36 and 48 ft. per minute, while the return speed is constant at approximately 100 ft. per minute. Feeds that are easily varied are obtained through a friction disc.

On the same stand is to be seen the largest and one of the most exceptional designs of machine tools in the Exhibition. This is the 100-in. Stirk Hiloplane, which is illustrated in Fig. 112, Plate XLI. When it is remembered that the weight of this tool is no less than 48 tons, it must be regarded as no mean accomplishment that it has been possible to erect for exhibition purposes, so that its running under working conditions may be studied.

The bed of the Hiloplane rests on the floor throughout its entire length, and is of the continuous plate type with double walls and solid bushed bearings. On the top, flat ways are provided for the table. This has adjustable side strips, and the tee slots in it are cut from the solid, while troughs are provided at each end for cuttings. The housings are firmly attached to the bed and connected to each other at the top by a deep tie bar. Two cutting heads are carried by the cross slide, which is raised and lowered by power through twin screws and enclosed worm gears. Side heads are provided on each of the side columns. The driving gears are made of steel throughout the machine, the first gear from the motor being of the double helical type. Automatic lubrication is given to the sliding ways by means of rollers in oil boxes, while sight feed lubricators serve for all the bearings on the bed. It will be seen that the special mechanical features of the machine are: continuous plate bed ensuring rigidity, the keyless change driving gear, and cross and vertical planing by main and side heads, which enables a saving of time in resetting of work.

The method of driving, however, is its most outstanding feature. This is the system of split field electrical driving designed by the firm, which makes possible a quick change in feed from ⅛ in. to 1½ in., while a magnetic relieving device is fitted to the machine for broad feeding. The electrical control is obtained by coupling a motor directly to the machine gearing, and this is supplied by current from a special generator driven by a suitable primary motor connected to the direct or alternating current supply. By manipulation of the magnetic field of the special generator it may be made to give a supply at variable voltage and in both directions. As the final motor which receives this current is independently excited, the variation of voltage gives alterations of the speed, and the change of polarity of the supply causes corresponding reversals in the direction of rotation. A graduated rocking disc with adjustable stops on it actuates contactors through a master switch, and effects the control of the table drive by the motor. The result is obtained through the use of two windings, or a split field as it is termed, on both the generator and the motor. In the case of the generator the two sections are connected to oppose each other so that they may be excited alternately to obtain the reversed polarity of the output. The motor field windings are arranged to work together. One of these is permanently excited and is for the production of the high speed for the return stroke, while the other comes into action to give the greater magnetic field necessary to obtain the slower speeds required for cutting. The range of speeds may be extended indefinitely by the variation of the generator voltage, and the standard equipment embodies two shunt regulators which enable the cutting and return speeds to be varied independently to any desired extent.

From the description of the arrangement it may be assumed that the gear is elaborate and necessitates special attention, but that is very far from being the case. The whole equipment is controlled by start and stop push buttons on both sides of the machine, and a separate inching button is provided. Features of the system are the use of regeneration at the end of the return stroke, and a simple accelerator is used to speed up, once the cut is started, and also in jumping gaps in the work. The accuracy and speed of reversal, and the ease of control are characteristics of the drive which are impressed upon the visitor to the Exhibition by the demonstration of the use of the system on actual work.

The split field system of driving a planing machine may appeal to many who have already got tools to which they would like to apply it, and for that reason Messrs. John Stirk and Sons, Limited, have designed and placed upon the market a conversion set which can be so used. This equipment is shown in Fig. 115, page 363. It consists of a direct or alternating current motor for driving, together with the generator and motor having the split field coil system and the requisite control gear, all on a common bed plate. All that it is necessary to do to apply the conversion set is to remove the old pulley from the shaft of the planer, and shorten the shaft to permit it being fitted to the coupling on the motor when the conversion set is in position

beside the planing machine. Equipment of this type suitable for working from direct current single, two- or three-phase alternating current at any voltage may now be obtained.

Messrs. Thomas Shanks and Co., Limited, of Johnstone, show an example of their planer drive system which is suitable for application to existing machines as well as for use in new models. In the design of this device an endeavour has been made to reduce the power that is lost through the stopping and restarting of the high speed pulley of the usual equipment. It is claimed that in doing so the firm has kept down the cost of the equipment to a small sum in comparison with any motor reversing system, while in point of efficiency and service it compares favourably with that system. The complete drive, which makes use of non-rotating magnets of annular form provided with energising coils, is housed in a circular casing made in two parts, bolted together, and with a cover which carries the gearing and the drive is through pinions and gears to a spur wheel. On the other side of the head is another similar wheel. The two wheels run on trunnions about three-quarters of their diameter, in bushed bearings, and connection is made between them by an adjustable eccentric crank pin off which the slotter head is taken. This drive is similar to that fitted to the puncher slotter of which a view is given in Fig. 114, Plate XLI, and our remarks will be rather more clear if for the moment we refer to this illustration. On the large wheel there shown is a block cut with teeth and gearing with a small pinion. The toothed block has two bolts as shown. One runs right through to the wheel on the far side of the machine; the other is merely a locking bolt, while the small pinion is also a locking device. The crank bolt is eccentric to the block, and by rotating the disc relatively to the wheel the throw can be changed. This is effected by slacking off the nuts and working the rim of the large wheel round, an indicator showing the length of stroke at any point. The setting is

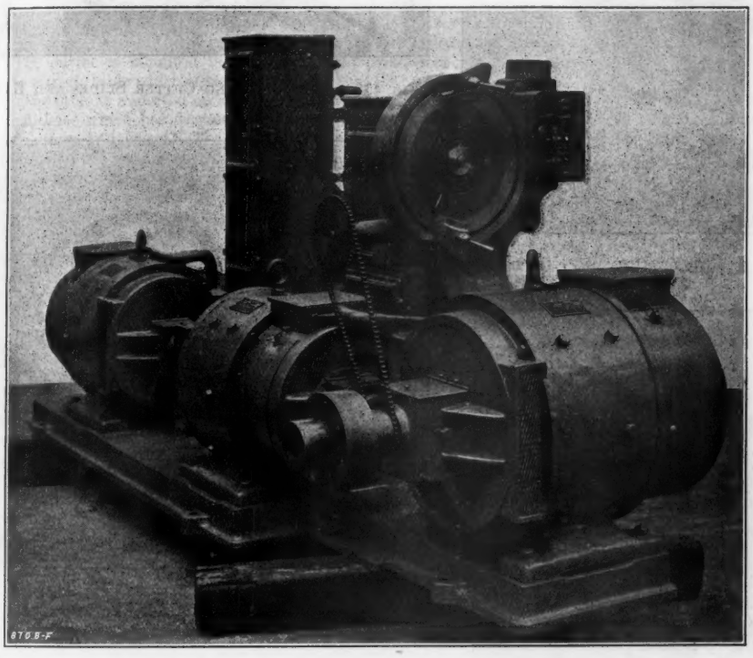


FIG. 115. SPLIT FIELD PLANER CONVERSION SET; MESSRS. JOHN STIRK AND SONS, LIMITED.

lever for changing the cutting speed. Two substantial bearings support the driving shaft within the housing and one end of it is left free for coupling to the machine by the necessary gears.

SLOTTING MACHINES.

Three slotting machines are exhibited by the Butler Machine Tool Company, Limited, Halifax. Two of these are of the ordinary type, while the third is a new puncher slotter. The two former are a 10-in. stroke machine and a 14-in. machine. The 10-in. machine is similar to 8 in. and 12 in. sizes by the same firm, while the 14 in. is representative also of 20 in. and 26 in. stroke machines. The smaller class has a change gear box in the body of the machine. The drive is by motor and short belt to fast and loose pulleys. The operation of belt shifting applies a brake to the flywheel. The slotting head is driven by Whitworth quick return motion. A scroll cam on the crankshaft imparts a rocking movement to a bell crank having a slotted arm, off which the adjustable ratchet feed movement is taken. The gear-box gives changes of speed ranging from 27 cycles to 65 cycles per minute.

The larger machine is illustrated in Fig. 113 Plate XLI. The drive in this case is on the Butler eccentric system, from a 12 b.h.p. motor running at 990 r.p.m., and mounted as shown at the back of the column. The motor is by the English Electric Company, Limited. From the motor the locked by tightening up all three nuts. The crank is furnished with a gun-metal die. This slides in a steel link.

Reverting now to Fig. 113, on the face of the wheel on the far side of the machine is a large cam roller path, and in this runs a roller on the end of a bell-crank lever. The second arm of this is slotted, and from it is taken by an adjustable rod, a ratchet feed motion which is transmitted through the base to the small box on the bed to be seen close to the column. This contains bevels which transmit the motion to the slide and table. From the motor a belt drive is also taken to a small supplementary countershaft mounting (see Fig. 113) and thence to the horizontal feed shaft. This drive provides the quick traversing motion, and a lever controlling two clutches throws in either this quick traverse or the slow ratchet feed as required. The slide is fitted with a circular revolving table, and hand feed ratchet feed or quick power traverse are available for all movements of the slide as well as the rotation of the table. The starting lever seen on the side of the column is interlocked with the quick power traverse, so that the head cannot be clutched in when the quick traverse is operating. This is effected by the slanting locking bar shown in Fig. 113. To operate the starting lever this bar has to be cleared from a notch in a disc on the starting lever spindle. This, however, is prevented when the quick traverse is engaged by a lug on the disc at the end of the upper of the two horizontal shafts, fouling the locking bar. The speed changes are obtained by gears in the trunk of the machine, and the range covers from 13 to 28 cycles per minute. The clutch lever applies a brake to the slotter head motion so that the ram may be stopped where required.

The puncher slotter illustrated in Fig. 114 is a very powerful machine, built for the heaviest work, such as cutting out crank axle webs, spring buckles, &c. In many respects it is similar to the previous machine, and the description of the eccentric drive need not therefore be repeated. This machine has no quick power traverse, but, the feed transmission being by gearing, feed trips are provided. The machine is driven by a 20 brake horse-power motor by the English Electric Company, Limited, running at 920 r.p.m. The motor drives through a Fabroil pinion into staggered laminated tooth spur. The speed changes are four in number, ranging between 11 and 33 cycles per minute. The feed is by ratchet, derived, as in the previous case, from a bell crank motion driven off a cam on the wheel on the far side of the machine (Fig. 114). The feed is thrown in by clutch.

The machine is exceedingly substantial, having a 6-in. flange to the base while the base and upright trunk are all one casting. The table measures 30 in. square, the in-traverse being 12 in. and cross traverse 30 in. The motor is controlled by a Brookhirst panel, and stop and inching push buttons are fixed at two points on the machine. The head is shown with a single tool holder. A double tool head can also be used. The tools are held in holders on the head giving slight relief for the up-stroke. The machine will work well up to 15 or even 12 cuts per inch. The inside of the bed is used as a tank for the cutting lubricant; a pump worked off the main drive is arranged for this on the far side of the machine. As an instance of the work which this machine will do we may give some figures for buckles, the machine cutting square holes 7 in. by 3 in. in steel 3 in. thick. With two tools the output is 32 buckles in eight hours, and on a duplex machine with four tools the output is 60 in eight hours.

GEAR PLANERS.

We conclude our account this week of reciprocating cutting tools at the Exhibition by reference to the Sunderland gear planers, shown by Messrs. J. Parkinson and Son, of Shipley. These machines will be familiar to many of our readers. On the occasion of the last Exhibition we illustrated Messrs. J. Parkinson's No. 5A type of planer. A machine of practically the same design is being shown at the present Exhibition, set for double cutting, on two wheels. Reference to our former article (vol. cx, page 363) will explain how these machines may be set for cutting helical gears, an illustration having then been given of one being cut on the 5A machine. An interesting development which has arisen since that date is the adaptation of the Sunderland machine to cutting double helical gears. A new machine of this class is being shown by Messrs. J. Parkinson at the present exhibition, made by arrangement with Messrs. David Brown and Sons (Huddersfield), Limited. This machine is illustrated in Figs. 116 to 118, page 364. The machine has a capacity for cutting gears up to 48 in. in diameter with 10 in. face, and up to 2½ D.P. The principle of construction is similar to the former machines, but instead of a single horizontal or inclined slide, two slides are employed, set at an angle of 22½ deg. This angle for the spiral cannot be altered and there is, therefore, no risk of wrong setting up. The cutters are similar to the rack cutters used on the other Sunderland machines, except that the rack teeth are inclined at the spiral angle. The reciprocating motion causes the cutters to enter the work alternately, and there is no risk of fouling. Double helical continuous teeth can be cut to a dead line, and finishing by any other process, subsequently, is unnecessary.

The machine is driven by belt of 4 in. width on to fast and loose pulleys on the machine, 16 in. in diameter and running at 330 r.p.m. Changes of speed are obtained with change gears; changes of feed by four-stepped pulleys, shown in Figs. 116 and 117. The drive is very similar to former machines, but the drive of the reciprocating slides

DOUBLE HELICAL GEAR PLANER AT THE MACHINE TOOL EXHIBITION.

CONSTRUCTED BY MESSRS. J. PARKINSON AND SON, ENGINEERS, SHIPLEY.

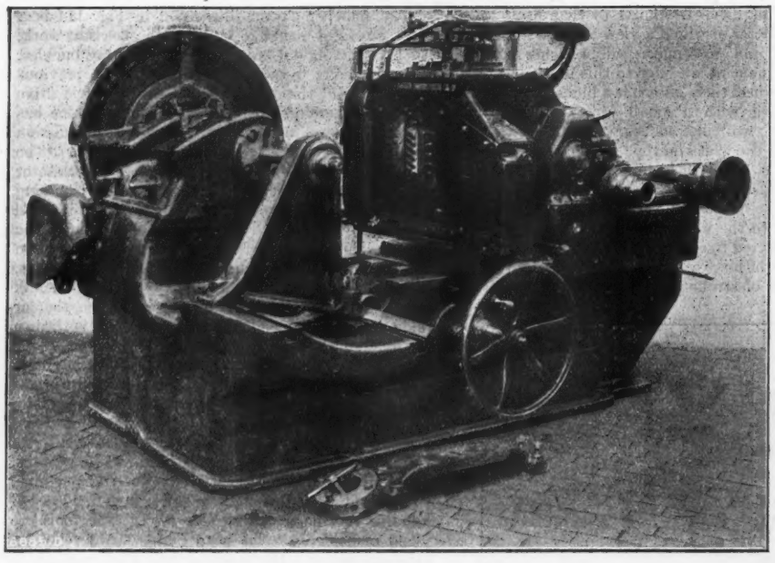


FIG. 116. GENERAL VIEW OF MACHINE.

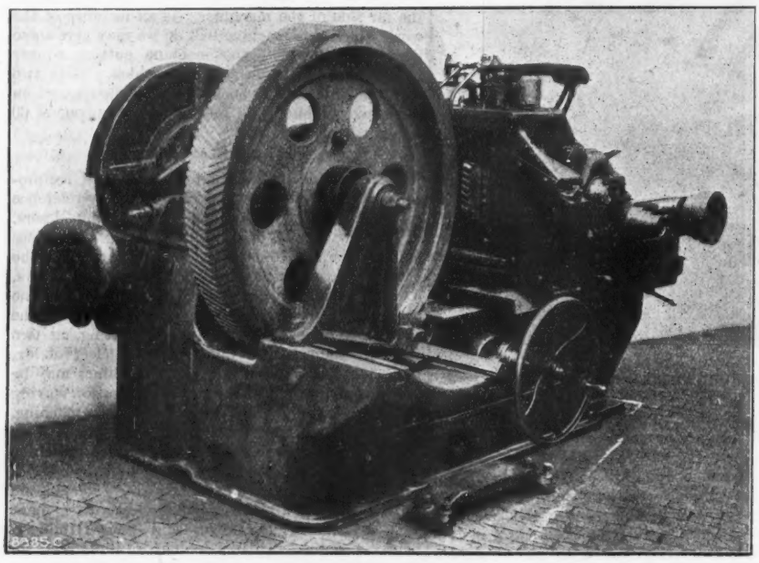


FIG. 117. 48-IN. DOUBLE HELICAL GEAR BEING CUT.

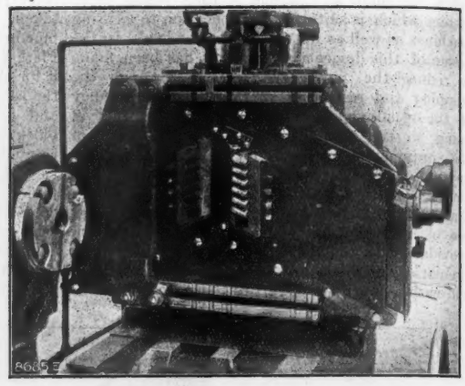


FIG. 118. VIEW SHOWING CUTTER SLIDES AND HEAD.

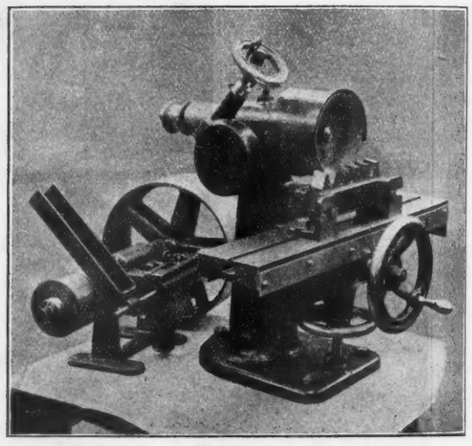


FIG. 119. GRINDER FOR SUNDERLAND GEAR PLANER CUTTERS.

is duplicated, there being two cranks driven off two helical gears in mesh. The cranks work the cutters to and fro. As the work proceeds the whole cutter slide is fed downwards, and at the same time the work is rotated. At the end of the vertical travel of the tool slide the cutters are withdrawn and the slide is moved up again to its highest position. This movement corresponds with one pitch of the teeth being cut, and on the completion of this traverse the cutters are again brought in to the work, and development of a new tooth on the work is begun.

It is difficult to do justice to the mechanism of this tool without diagrams. The principal points however, may be touched on. Apart from the cutter drive, two drives by worm and worm-wheel are embodied in the machine, one being a high-speed drive, and the other of a lower speed, through the belt and pair of cone pulleys at the side of the machine. Both drives connect through to the cutter vertical feed and to the index worm-wheel drive. The fast drive is intermittent, as it embodies a pawl and ratchet, which for part of the cycle are held out of engagement by a timing plate.

The normal cutting feed is derived from the cone pulley slow-speed gear which drives a train of gear wheels through a set of ratchets, but when the fast gear is engaged the latter overtakes the slow drive and the ratchets of the slow drive click over idle. When this occurs the vertical movement to the cutter slide is at a quick rate, but when this gear is in, the direction is reversed, so that the fast rate is only employed when the slide is being returned to its top position to recommence a downward cutting stroke. The timing of this fast drive to the slide motion is controlled by a second timing plate, tripping a pawl and allowing it to re-engage at the required moment. The work indexing drive is also intermittent, but always in one direction. It is taken off the reversing gear by a train which also includes a ratchet movement. When in what may be termed forward gear, and the cutters are being fed downwards in their working stroke, the indexing wormwheel drive is operative in a corresponding degree, so that the work and rack are moving in rolling unison. When the head is withdrawn and the feed train is reversed to return the slide to the top again, the ratchet of the indexing train operates and the index wormwheel and work remain stationary.

In the Sunderland gear planer previously described the cutters are withdrawn from the work by moving the whole head away from the work blank. In the machine under notice this is not done, the head remaining where set throughout the operation. After each stroke, the tools are given a positive relief movement in the slides by a motion taken off the drive, and when the downward feed is completed the same gear withdraws the cutters and blocks completely so that they clear the work, and the slide can be traversed vertically for the commencement of a new stroke. The cutters are ground in this instance over the whole face and are finished on the ends, so that when placed in the block of the head they must be correctly set. As the grinding of the inclined teeth to a flat face would give an unsuitable edge on one side of the rack tooth, for cutting this edge is slightly ground hollow so as to give it practically a curved lip.

The work blank is mounted on an arbor carried in bearings, the arbor being connected with the shaft of the indexing worm wheel. This spindle is hollow, and shafts can be inserted through it so

that it is possible to cut, on the machine, pinions solid with their shafts. The work is supported laterally by bridge pieces one of which is shown on the head in Figs. 116 and 118, while the other is to be seen in Figs. 116 and 117, lying by the side of the machine on the ground. To ensure the central line of the double helix being properly positioned, the work spindle headstock is mounted on a slide and can be adjusted endwise by screws. All controls are conveniently brought together at the front of the machine. The planer will cut continuous interrupted or staggered teeth equally well. The smallest gear cut has a bottom diameter of 2½ in.

In the process of grinding, the cutters are naturally reduced in thickness, and, in order to utilise them down to the utmost limit, backing plates are used to give support to the teeth. Fig. 119 illustrates a little machine made by Messrs. J. Parkinson and Son, for sharpening Sunderland gear planer cutters, a straight cutter being shown mounted on the table, in the illustration. The machine hardly requires explanation. The cup grinding wheel is 6 in. in diameter by 2¾ in. wide. It is fed forward by hand-wheel and worm operating a wormwheel, pinion and rack. The cutter is mounted in a special clamp bolted to a work table which is traversed across the wheel. The table is mounted on a Vee and flat face on a small knee which has vertical adjustment by elevating screw and wheel. The spindle runs on ball bearings and is belt driven from a countershaft. A trunk casing is often used, connected with an exhausting system, but we have illustrated the machine fitted with the plain guard in order that the wheel, etc., might be more clearly seen. The little appliance can, of course, be utilised for surface grinding.

(To be continued.)

THE IRON AND STEEL INSTITUTE.

SIR WILLIAM H. ELLIS, in opening the proceedings at the meeting of the Institute, on Thursday morning, the 4th inst., stated that under the new bye-law he would vacate the chair at the next Spring meeting. It had always been the custom to announce the name of the new President at the preceding Autumn meeting. The Council had selected four gentlemen, either vice-presidents or members of Council, to succeed him in the chair; these were Professor H. Le Chatelier, Mr. W. H. Hewlett, Mr. E. Steer and Mr. C. J. Bagley. All of these gentlemen were unable to accept the Council's invitation to become President of the Institute, on account of age and of their present very onerous duties and responsibilities. He expressed the hope that the new bye-law, according to which the President was elected for one year only, would, as a rule, apply, unless altered by very exceptional circumstances, so that the loss to the Presidentship of four such gentlemen as those named above might not be experienced in the future. As a mark of esteem, the Council had elected them Hon. Vice-Presidents of the Institute. Sir William then announced that Sir Frederick Mills, Bart., had agreed to be the next President. Colonel Sir W. C. Wright, Mr. F. W. Harbord and Mr. W. R. Lysaght had been proposed as Vice-Presidents, and in their place as members of Council, it was intended to appoint Professor Desch, Captain V. Beardmore Stewart, and Mr. W. Simons.

Sir William Ellis then said that although the Institute was primarily concerned with the study of the technical side of the iron and steel industry, it was impossible not to say a few words on the very serious position of the industry at the present time. This was a commercial question, but it was so closely associated with the work of the Institute that he wanted to give a few moments consideration to it. There never had been a more suitable occasion than existed to-day for the proper appreciation of the researches of the members, both past and present, who had been closely studying the scientific side of metallurgy, as an aid to furthering the industry. Iron and steel manufacture had now to contend with most formidable difficulties, financial and others. Our competitors had renewed their plant and equipment since the war; we had not been able to do so owing to depleted finances. This country's difficulties would increase by the failure to recognise the practical value of modern equipment. The criticisms put forward in this connection by every member of a works' staff should be duly listened to. Plant renewal and the adoption of all labour-saving devices were now absolutely essential to us, as well as complete collaboration between engineers and metallurgists, and between these and all the members of the works' staff. The steelmaker and the maintenance engineer were well equipped with practical knowledge, but they very frequently had to carry on their duty whilst bearing also the weight of administrative routine work. Full advantage should be taken of the younger men, technically trained and having knowledge of modern methods of manufacture; suggestions from these on fuel economy, machinery equipment, electric working and so forth, could form bases upon which the steelmaker, maintenance and other engineers, in actual charge, could start their own consideration of the problems involved, on which they would bring to bear the weight of their own experience. For this country to be able to compete—and it was now fighting for its very existence—full advantage would have to be taken of all the advances made in the scientific studies of metallurgical problems.

PICKLING AND HYDROGEN DIFFUSION.

The first paper taken had for its title "Pickling; or the Action of Acid Solutions on Mild Steel and the Diffusion of Hydrogen through the Metal," by Professor C. A. Edwards, who read it in abstract.

Professor Edwards explained the manufacture of steel sheets used for tinplate manufacture, namely, their rolling, doubling and re-rolling, each sheet in the finished bundle being separated from its neighbour by a film of oxide of iron, the final rolling operations being carried out at a good red heat. When pickling the sheets, the hydrogen generated by the acid was not freely liberated from the bath; some diffused in the metal and produced hydrogen brittleness. He had taken up the question with a view to investigate the "peppery blisters" frequently formed in tinplates. He explained that whilst isolated patches of oxide might give rise to blisters, it did not seem necessary to postulate that reduction of this oxide needed to take place. Undissolved impurities, or constituents as carbide of iron and manganese sulphide, might behave, in this respect, in the same manner as oxide of iron. He showed in a diagram an inclusion in iron and pointed out how the hydrogen atoms entered, passing from one atom of iron to another until the hydrogen reached the boundary of the inclusion. Molecular hydrogen accumulated at the boundary, the amount of entrapped gas continued to increase so long as pickling continued. In very thin plates the internal pressure at the inclusion became so great as to cause a blister by forcing out the surfaces of the sheet. The amount of hydrogen thus accumulated was a function of the duration of pickling, of the distance of the inclusion from the surface being acted upon by the acid, the strength of the acid and temperature; it increased with time, temperature and acidity, but was inversely proportional to the distance. The author explained the apparatus he had devised by which he made quantitative measurements of the rate at which hydrogen diffused through iron and steel, under varying conditions of acidity and temperature. The rate of diffusion was considerably quicker with sulphuric acid solutions than with hydrochloric acid solutions of corresponding acidities. Electrolytical pickling was also investigated and its results were satisfactory, a specimen illustrated showing no blisters. Experiments made with specimens containing only one crystal showed that the hydrogen passed through this quite readily.

Mr. J. H. Whiteley thought that if hydrogen in the molecular state could collect in sufficient quantities to lead to blisters, evidence of a separation in the metal giving rise to cavities could be obtained by the microscope. The embrittling action of hydrogen was well known. He had sent out a steel plate for an oil press; when delivered it showed a tensile strength of 27½ tons per square inch and 30 per cent. elongation. This plate ultimately came back to the works and was found to be very brittle. Microscopic examination showed no evidence of brittleness. Normalising restored to the plate its former test figures. The percentage of hydrogen was found to be quite extraordinarily low. It might be asked whether the passage of hydrogen through the metal should be considered rather than its presence in the metal.

Mr. E. F. Law said that the subject had been brought before the Institute many years ago and he was glad Professor Edwards had dealt with it afresh, since it was an important one for many members. The tinplate manufacturers of South Wales were large consumers of acid; large amounts of steel were lost by dissolution in the acid in the course of a year. Adding to this the galvanising industry, it would be seen that both the tinplating and galvanising processes were important ones in the country and saving in manufacture would result in greatly improved assets. He did not quite agree with the author's theory of blisters. According to the author, hydrogen penetrated the steel until it met an inclusion, an impurity, and accumulated in molecular form, leading to a blister. The author had said it was impossible to state with any degree of finality that manganese sulphide would, or would not, behave like oxide inclusions, but was very much inclined to believe that it would. He (the speaker) thought it did not so behave; if it did there would be still more blisters than occurred now, for there was manganese sulphide in every plate. He thought that when the author went more fully into the matter he would conclude that the "peppery blisters" were due to reduction of oxide.

Mr. C. H. Ridsdale, referring to his previous work on the subject, said his facts still held good although they had been stated twenty-three years ago. He had arrived at the conclusion that a microscopic lamination was the cause of the trouble. He had dealt at the time with the subject more from the commercial side, and one of the earliest facts he established was that too long pickling gave rise to the blisters, although the steel beforehand was satisfactory. Taking the same bars, the overheating of some for various periods also led to blister formation; the case was similar with the outside sheets of a pack, and with the slightly aired sheets out of the annealing box. In the ordinary course of manufacture a sheet underwent as much work as it possibly could stand; if it were subjected to just a little more heat, or a slightly longer pickling time, blisters would be formed. In some of his own work he had found some patent oxidising agents of value.

Dr. Rosenhain questioned the author's theory of the diffusion of hydrogen; it was hydrogen ions carrying an electric charge which led to the occurrence, and he could not see how hydrogen ions went through a crystal. He doubted whether there were no air spaces in the sheet thickness; if there were cavities they would fill up with hydrogen The gassing of copper was well known. An aluminium sheet might roll well, and on annealing blisters would occur, as in the tinplates referred to by the author, and this was a question of the gas content.

Dr. W. H. Hatfield, in regard to blisters, did not find the author's explanations convincing, nor those put forward by Mr. Law. The question had to be viewed from two aspects, the embrittling action of the acid, and the blisters. In regard to embrittling, one was dealing with a thin sheet of steel, attacked by acid, tested after pickling without polishing the test piece; the roughening action of the acid caused the steel to behave as brittle, whilst it was not brittle. The question of blisters was a very important commercial one and a difficult one. In his view, when rolling there occurred an imprisonment of gas under high pressure in the locality of an oxidising slag inclusion. By pickling, a part of the metal thickness covering the imprisoned gas was dissolved, changing, as it were, a strong vessel containing gas into a flimsy one. Cementing wrought iron gave blister steel, where an analogous action took place. He was gratified to hear that the author had found the hydrogen to pass through a single crystal quite readily.

Engineer Captain J. A. Richards gave his experience of blisters occurring in boiler tubes, and Mr. Stromeyer also referred to boiler tubes which

had developed pitting to such an extent that they had to be removed after the first voyage. In future, he would examine tubes from the blister point of view.

Sir William Ellis asked the author why the electrolytic method of pickling was not followed, since it did not lead to the blister effect.

In the course of a brief reply, Professor Edwards thought it would be very difficult to use the microscope in the detections as suggested by Mr. Whiteley. The amount of hydrogen absorbed was not small when considering the matter fully. Great care had to be taken in measuring the hydrogen absorbed by the steel as a result of pickling. The experiments had to be carried out immediately after pickling; the time factor had to be borne in mind. He did not think Mr. Law was quite right in saying that manganese sulphide did not give blisters; some men in the trade believed that manganese sulphide was the cause of them. He (Professor Edwards) did not specify the oxidising agents he had tried so as not to mislead anyone until they were fully tested, but he did not use any patent solution. His diagram illustrating hydrogen diffusion was not intended to describe the path of the hydrogen, but to give a picture of what was proceeding in the metal. In regard to embrittling and Dr. Hatfield's remarks, the roughening action of the acid could not be neglected in testing. In the matter of electrolytic pickling as against acid pickling, this was entirely a question of cost.

Free Surfaces and Plastic Deformation of Metals.

The next paper dealt with "The Effect of Free Surfaces on the Plastic Deformation of Certain Metals," by Dr. F. C. Thompson and Mr. W. E. W. Millington. It was read in abstract by the former.

This paper was a continuation of former work by the same authors, reported in our last volume on pages 344, 353 and 631. It confirmed their former work in every particular, and, Dr. Thompson added, had an important and distinct practical bearing on manufacture from the point of view of the engineer. The authors in the present paper gave reasons for believing that at the free surfaces deformation would probably differ distinctly from that within the mass. In close-packed cubic material (gamma iron and many of the non-ferrous metals) the deformation was considered to be effected in its earlier stages by the "easy glide" of the atoms on the octahedral planes. Such movement appeared of necessity to be restrained by the crystal boundaries, and at the free surfaces, where there was a partial removal of this restraint, it was not difficult to imagine that the atomic movement would be more easily initiated; in other words, the elastic limit would be lower at the surface than it was internally. Points brought out were to the effect that elastic failure was controlled by the free surfaces, and that the elastic limit variation was not due to the structure but to the surface.

Dr. D. Hanson said he was now more in agreement with the authors than he was formerly, but he did not go quite so far as they did; he did not agree with them when they said that the observation of the stress at which slip-bands first made their appearance was practically valueless for the purpose. The surface could only strain as it was allowed to do so by the elastic-strained interior. The outside layer moved and the inside as well. Their suggestion that the elastic limit was lower at the outer layers than in the interior was an interesting one. He questioned the authors' figures for safe range of stress in the Haigh fatigue test. They gave 11·5 tons per square inch for annealed copper and 37 tons per square inch for annealed nickel. He also disagreed from their elastic limits for these same materials. Both sets of figures were much too high.

Professor Edwards would have liked the paper to include accounts of actual experiments carried out by the authors. He found that the authors' quotation of Professor Unwin's figures were insufficient in themselves without adding the conditions under which Professor Unwin's test specimens were obtained. The same remark applied to their quotation of figures for wires. Dr. W. H. Hatfield agreed with these remarks by Professor Edwards.

Professor Thompson, in his reply, with reference to the Unwin figures, said they were careful to note in the paper that it would probably be possible to discredit any one of the set, but since they all pointed in the same direction and to the conclusion that as the surface increased the elastic limit fell, the combined value of all the results was cumulative. In the matter of the figures giving the physical properties of annealed steel wires of varying diameters, Professor Thompson added that in their (the authors') diagram, the points fell well on the lines which their theory demanded. The case was the same with the results of Tammann, Jeffries and others, all these pointing in the direction in which they (the authors) required them to point. Professor Thompson also called attention to the paper by Professor Edwards and Mr. Pfeil, in the matter of surface deformation, and in quoting this and an earlier one by Professor Carpenter, said that the essential difference between iron and aluminium in respect of the surface film of small crystals pointed strongly to the fact that in the former metal the nature of deformation at the surface differed from that away from the surface, whilst in the close-packed metal the surface films of crystals, when they did occur, were more probably to be ascribed merely to variations in the extent of the preliminary deformation.

On the members re-assembling on the morning of Friday, the 5th inst., the chairman gave the names of the Vice-Presidents and Members of Council who were retiring according to the bye-laws, and who offered themselves for re-election.

Ferrous Alloys Research.

The first papers taken consisted of a joint contribution by Mr. F. S. Tritton and Dr. D. Hanson, on "Iron and Oxygen," and one by Mr. T. E. Rooney, on "The Estimation of Oxygen in Pure Iron." Both were read in abstract. They were preceded by an introduction by Dr. Rosenhain, who stated that they contained the first results of a research on the alloys of iron which was commenced about a year ago under the auspices of the newly-formed Ferrous Alloys Research Association. Dr. Rosenhain had suggested to the Alloys Research Committee that the study of alloys of iron, apart from those in the form of steel, was a desirable one, and the suggestion was warmly approved by the Committee. Dr. Rosenhain alluded to the great interest which Sir John Dewrance was taking in the work of the Ferrous Alloys Research Committee, a committee composed of the leading scientific and technical societies and institutions of the country. He also gave an outline of the various difficulties which the authors had had to overcome in connection with the researches dealt with in the papers then before the meeting. The whole of the work was done at the National Physical Laboratory.

Mr. Tritton detailed the work which had been carried out for the determination of the constitution of the iron-oxygen alloys and the effect of oxygen on the mechanical and physical properties. The purest iron readily available at first was Armco iron, and this was taken, but later it was found to be unsuitable, and arrangements were made to produce at the Laboratory electrolytic iron in the necessary quantities. The average analysis of the material as deposited was: carbon, trace, and no silicon, sulphur, phosphorus and manganese. With this, ferric oxide was used, containing silicon, 0·16 per cent.; sulphur 0·044 per cent., and phosphorus, trace. One of the greatest difficulties was to obtain suitable pots and refractories. These were ultimately manufactured at the Laboratory, where a method was developed for producing pots of a new shape and having internally-glazed surfaces, of great resistance to chemical attack, the glazing produced by means of direct fusion of the refractory in an electric arc. The Laboratory pots were the only kind able to hold molten iron and iron-oxide at the same time. A high-frequency, induction Ajax-Northrupp furnace was used; it made possible the melting of iron in vacuo or hydrogen. The paper also detailed the improvements made in the thermo-couples and the taking of cooling curves from 1,530 deg. C. Varying oxide contents were found to have no influence on the lower critical points. The solubility of oxide in iron and other points were gone into in detail. From the results, the authors were able to draw a very simple constitutional diagram of the system. The ingots were hot-rolled into rods. Attempts to cold-roll a bar of high-oxgyen iron, giving a very small reduction, at once caused severe cracking, and were abandoned. The paper gave the electrical conductivity, magnetic permeability, tensile tests, impact, and other tests of the alloy, the effect of cupric reagents and of case-hardening oxygen-iron alloys.

The second paper, by Mr. Rooney, described the investigations for the estimation of oxygen in pure iron and the apparatus used.

Sir William Ellis referred to the liberal way in which Sir John Dewrance had helped financially to carry out work such as that then under consideration, a work which could only be undertaken by an establishment such as the National Physical Laboratory. Industrial establishments could not possibly concentrate on researches of this nature, nor could they provide the time and the staff. With iron-oxygen alloys the task was only at its beginning, and it could only be continued if the various institutions forming part of the Ferrous Alloys Research Committee continued, on their part, to provide the funds.

Sir Robert Hadfield, speaking as one of the members of the Committee, said no one better than Dr. Rosenhain could have been found to supervise the research; the Committee might feel quite safe in his hands. Sir Robert also paid a tribute to Sir John Dewrance for providing money for the work at a time when funds were not easily available; Sir John would feel satisfied with the first results achieved. But the work was going to be a most formidable one, since the number of binary alloys could extend to 230, the ternary to 2,530, and the quarternary to 17,710. These figures would give an idea of the work before the Research Committee. Dr. Rosenhain had done well to investigate first pure iron itself. He (Sir Robert) looked forward to the investigations in iron and manganese in the absence of carbon. Before the war he had started researches in that direction, but had been compelled to stop them; he might put forward his results later to compare them with others made on the lines of the papers then before the meeting. The effect of copper in an alloy was at first passed over; it had been ascertained since that it had a great influence. The same could be said of the effect of gases. When carbon was present, its form and particular carbide had to be ascertained. There had to be investigated also the physical quality of the material, its characteristics as cast, its toughness, tenacity, elongation, reduction of area, tests figures, durability, corrodibility, and so forth, all of which points showed the extent of the work still to be done. This work, he repeated, had been started on a good basis by the National Physical Laboratory.

Dr. Desch found that the authors had begun with one of the most difficult systems, one which had been abandoned by the Washington research authorities, their vessels not being able to resist the action of the iron oxide. The authors had shown remarkable skill in the manufacture of apparatus for overcoming these difficulties. Their constitutional diagram well represented the conditions of the iron-oxygen alloy. The glazing of the inside of the crucibles by direct fusion of the refractory in an electric arc seemed a good process, and most laboratories would now improve their crucibles in the same way. The authors, by their improvement of the Ajax-Northrupp furnace, had sacrificed themselves in the interest of other workers, since the makers of the furnace now used the experience gained by the National Physical Laboratory, and embodied the improvement in furnaces supplied to other researchers. The author's case-hardening tests of two samples having high or low oxygen contents, together with one of ordinary case-hardening steel, the microscopic examination of which specimens showed the depth of penetration by the carbon to be quite unaffected by the presence of oxide, were, Dr. Desel thought, remarkable, the depth of case being the same for all three specimens. He could not see any fault in the authors' statements in the matter of these particular tests.

Dr. W. H. Hatfield said that the part of the

authors' constitutional diagram up to 0·2 of oxygen should receive more extended investigation, and asked whether the authors could state what was the equilibrium content of oxygen under an oxidising slag in an open-hearth furnace. He would be able to send the authors a number of ferrous products with a view to obtaining from them reliable data as to the oxygen, the oxygen determination being a very difficult one.

Professor Carpenter referred to the authors' statement with reference to iron containing about 0·08 per cent. of oxygen, with which no difference was observed in the arrest points, the freezing point being 1,535 deg. C., when referred to the melting point of palladium taken as 1,555 deg. C. He said he had found 1,519 deg. C. on the optical scale; he took no means to exclude oxygen, but the difference was only 16 deg. C. Oxygen would thus seem to have no influence on the freezing point. The simplicity of the authors' constitutional diagram greatly appealed to him and would also appeal to his students.

Professor Louis said the paper dealt with the solubility of oxygen in iron; should it not be rather the solubility of oxide of iron? He also objected to the term alloy when speaking of iron and oxygen, since an alloy was a combination of two or more metals.

Colonel Belaiew asked what was the actual influence of oxygen on iron in solid solution; it did not appear so great as one had been led to believe previously. He also pointed out the difference in the influence of an impurity following the structure of that impurity—spherodised oxides, for example.

Mr. F. W. Harbord suggested that there would be a great difference in the alloy when iron was melted in the presence of an oxide, and when the alloy was obtained in a Bessemer converter, and suggested a consideration of this point.

Mr. J. E. Fletcher, like Professor Carpenter, greatly appreciated the authors' constitutional diagram, and confirmed Mr. Harbord's remarks. The method mentioned of obtaining the internal glazed surface, as well as the other practical points covered, would prove of great help to manufacturers.

Mr. J. H. Whiteley found the paper interesting in connection with the reactions which took place in the open-hearth furnace.

Dr. Hanson, in his reply, agreed with Dr. Hatfield that the diagram up to 0·2 of oxygen would require further investigation; it might be that the difficulty in that region was due to the refractories. In all their iron saturated with oxygen—or oxides—the results showed that there were no deleterious effects on the iron, although brittleness was set up under impact; one of the causes of this brittleness might be the coarse grain-size of the iron. The extension of the researches to the open-hearth furnace would have to be made; the slag layer in the furnace was not, however, a simple iron oxide. With regard to Colonel Belaiew's remarks, the effect of the oxide was greater when distributed in different forms; there were some rounded oxide particles, but they did not have much influence upon the embrittling action. There would probably be more oxide in blown metal than when melting the iron and oxide together.

Dr. Rosenhain acknowledged the financial help received by them for these researches; the work was a most complicated and lengthy one, and they had to rely on similar aid in the future for its continuation. As to the nomenclature and in reply to Professor Louis, it was more correct to say "oxygen" than "oxide of iron"; in solid solution it was present in atoms, and the authors were justified in calling the system the "iron-oxygen system." Further, in regard to alloys, there was the iron and carbon system, among many others, and one could not call carbon a metal, nor any other non-metallic component of other alloys.

The Hardening of Steel.

The second paper dealt with "The Hardening of Steel," by Dr. Rosenhain, who read it in abstract. It was not discussed at the meeting owing to lack of time. We reproduce it in a slightly abridged form on page 391 of the present issue.

Hard Steel Balls.

The last contribution was on "Improvements in the Brinell Test on Hardened Steel, including a New Method of Producing Hard Steel Balls," by Mr. A. Hultgren, Gothenburg, who read it in abstract.

It stated that the Brinell balls were generally made of high carbon steel (carbon about 1·20 per cent.), sometimes containing chromium, usually not above 1 per cent. They were hardened in water and not tempered, or tempered at low temperature. They represented the maximum hardness generally obtained in hardened steel articles, namely about 700 Brinell. Chromium-tungsten steel balls were somewhat harder, but not sufficiently so to enable accurate hardness determinations to be made on these very hard steels. The author made attempts to produce balls of increased hardness of alloy steels, containing tungsten in one instance, chromium and silicon in another, but these were not successful. Somewhat better results were obtained by special heat treatment using a steel containing carbon 1·10 per cent. and chromium 0·60 per cent. The balls were first heated to 900 deg. C. and cooled in boiling water, thus producing a homogeneous sorbitic structure; they were then hardened from 760 deg. C. in water and left untempered. The resulting structure consisted of extremely fine martensite with the hypereutectical cementite distributed in numerous small grains. The hardness of the finished ball was distinctly greater than that of the ordinary Brinell balls and very uniform. The author then described his method for cold-working the balls, and the various tests he made with balls treated in different ways, including rebound tests. In order to obtain sharper definition of the impression he tried with success the use of etched balls; the impression with these was sharply defined and could be read easily and accurately with the microscope.

Sir Robert Hadfield referred to the author's statement to the effect that tempering of ordinary balls at 150 deg. C. did not lower the rebound hardness, but slightly raised it, whereas tempering at 225 deg. C. lowered the hardness to a marked extent. Sir Robert asked by how much it was lowered and whether the author could give the shock quality of such a material, so as to indicate by how much the toughness was increased. He also asked whether the author had gone above the 700 Brinell hardness number. If one could determine up to 800 it would be of great advantage.

Dr. Rosenhain stated that the dulling of the ball by etching was good in some ways, but he questioned whether it did not affect the reading. The rough surface increased friction and diminished the depth of the impression; it had some effect, but the question was whether this was measurable.

Mr. Hultgren referred to his table giving the results of his rebound tests, and showing that the balls tempered at 225 deg. C. had the lowest rebound value. He had not made shock tests on balls. He had not met with Brinell hardness values up to 800. The point in the remark by Dr. Rosenhain in regard to the dull ball had occurred to him (the author) and he had made comparative tests with the ordinary bright ball. With the latter, measurement was difficult. He had not found that the objection raised in the matter of the dull ball led to the difference suggested.

The other papers on the list were taken as read. We reproduced in part on page 347 *ante*, one "On the Nature of High Speed Steel," which we conclude on page 393 of the present issue. On page 351 *ante* we reproduced that on "The Changes of Volume of Steels during Heat Treatment."

All the authors received the thanks of the meeting for their contributions. Thanks to the Chairman concluded the proceedings.

THE BRITISH ASSOCIATION MEETING AT TORONTO.

(*Continued from page* 323.)

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

Radiation at Low Temperature.

The paper by Professor J. C. McLennan, F.R.S., of Toronto, on "Recent Developments in Low-Temperature Research," was taken at this stage because it dealt chiefly with the effect of cold on spectra. Saying a few words on his liquefaction plant, consisting of air, hydrogen and helium cycles—erected in the basement of the Physics Building in which the Section met—Professor McLennan mentioned that they had, three years ago, begun to liquefy helium (from the natural gas of the Calgary district) and could make half a ton of liquid air per day. Dewar vessels of glass being too fragile, they had had metal containers made, but had first to repair them frequently; some charcoal was placed in the vacuum jacket; the draw-off tube of a container was made by bending a ¾-in. tube of German silver and was provided with a safety trap to meet sudden rises in pressure. The coil of the hydrogen liquefier had its valve within a Dewar flask, from which a tubular expansion device (due to his assistant, Mr. G. M. Shrum, M.A.) extended outward; this tube opened out into a cylinder and narrowed again to a short tube, sliding in an outer tube; the whole was encased in another Dewar flask containing some blocks of charcoal. The hydrogen issuing from the valve blew any particles of solidified gases out through the tube, so that no clogging occurred. The liquid helium exhibited looked a colourless, quietly-boiling liquid; the liquid air was distinctly blue.

Passing to the researches, Professor McLennan stated that, if helium formed molecules at all, they should be more stable at low temperature, and the molecular spectrum bands should become more marked in the spectra as the temperature was lowered. His photographs, taken at the temperatures of the room, of liquid air and of liquid hydrogen (— 252 deg. C.), entirely confirmed that; the bands, indistinct at first, became enhanced. Stellar nebulæ seemed to contain molecules of both helium and of a hydrogen-helium compound at very low pressure and temperatures. As regards nitrogen, Vegard, now working at Leiden with Kammerlingh Onnes—whose advice on the construction of the helium plant Professor McLennan acknowledged—had stated that solid nitrogen gave a new spectrum, differing from the ordinary spectrum and containing the green line 5577, considered characteristic of aurorae. Professor McLennan could not support that; they measured three new lines in the vapour from solid nitrogen, but none near 5577. Nor had they observed this green line in helium, hydrogen, oxygen, neon, carbon dioxide or ammonia, so that the origin of the green line remained obscure. These last four substances did not phosphoresce, whilst solid nitrogen showed a brilliant green phosphorescence when bombarded with kathode rays, as Mr. Shrum demonstrated. For this purpose a glass tube containing liquid nitrogen was lowered into liquid hydrogen; a white snow of solid nitrogen settled on the inner glass wall, where it was bombarded by rays from a cathode mounted in the tube. The vapour pressure of the solid nitrogen was so low that the discharge would not pass until a trace of helium or hydrogen was introduced. The nitrogen had to be chemically prepared for the phosphorescence and the spectroscopic study; commercial nitrogen was too impure with neon. Solid hydrogen was also shown; when the hydrogen tube was joined to a Gaede pump, snowy crystals settled on the glass wall above the boiling liquid.

The Scattering of Light.

In his paper on "Controlled Orbital Transfers of Electrons in Optically-Excited Mercury Atoms," Professor R. W. Wood, of Baltimore, described further experiments with mercury vapours at various temperatures. Jacketing a quartz tube containing mercury vapour at 0·001 mm. pressure with a mercury arc lamp to illuminate the vapour by the ultraviolet rays of $\lambda 2536$, he observed peculiar effects when he closed the ends of the tube by prisms and filtered the light through bromine vapour and other colour screens for intensity measurements. The incoming rays, he explained, would expel an electron to an outer ring orbit; that would be accompanied by light absorption. The electron might revolve in that orbit or at once fall back, giving rise to a light emission; it might also receive a further impulse, leading to new absorption, falling back then to the temporary orbit or to the original orbit, again emitting radiations (triplets and

other lines). Thus there would be several "transfers" to different energy levels, which Professor Wood discussed at length. One of his peculiar, so far unexplained, observations was that the admixture of a trace of nitrogen to the mercury caused a powerful emission of the so-called "water band" in the ultraviolet, a 30-fold increase of the intensity of the line 2536, and a weakening of other lines.

Professor C. S. Raman, F.R.S., of Calcutta, followed with a long communication on the "Scattering of Light in Relation to the State of Molecular Aggregation." In conjunction with several collaborators (Messrs. Ramdas, Krishnan, Ganesan and Ramathan), he said, he had studied the scattering by gases and vapours, single and mixtures (oxygen, carbon dioxide, &c.) at pressures up to 150 atmospheres and found that the phenomena were best discussed with the aid of thermodynamic surfaces representing the properties of the gases. Liquid surfaces (mercury, alcohols, ether, benzene and 70 others, pure and freed of all dust) scattered more light in directions adjacent to the angle of regular reflection than in others and showed opalescence, which was also marked at the interfaces between two immiscible liquids; the transition from the liquid to the glassy amorphous condition could be investigated by observing the scattering. The want of planeness of the liquid surfaces was an important factor. Crystals always scattered a little when reflecting light, but with fresh cleavages there was hardly any reflection, and the surfaces might be invisible therefore; freshly-blown glass was opalescent. The light scattered by gases and vapours seemed to be the less polarised, the more complex the molecules. Professor Raman also discussed the scattering of X-rays considered as ideal gases, on Boltzmann's theory, and the relation of molecular anisotropy to constitution and to double refraction.

We mention two other papers. Professor F. B. Kendrick, of Toronto, on "Light Scattering of Aqueous Solution" (comparison of experimental and theoretical data of dust-free solutions); and Professor W. H. Martin on "The Depolarisation Factor of Scattered Light and the Electrical Double Refraction in Liquids." The latter did not observe any change in the depolarisation factor of nitrobenzene in a magnetic field of 5,000 gauss. A mathematical paper by Dr. L. B. Loeb, of California, on "Gas Ion Mobilities and their Independence of the Nature of the Ion," was taken as read. A paper by Professor Frank Allen, of Winnipeg, on "Visual Sensory Reflexes," dealt with colour vision and experiments on fatigue of the eye by monochromatic light, supporting the three-component colour theory of Young-Helmholtz.

Crystal Structure.

The delivery of Sir William Bragg's presidential address on "Crystal Structure"*—an unusually brilliant address, Sir E. Rutherford said in proposing a vote of thanks—was followed by a general discussion on the subject by Sections A and B. In a paper on "The Relation between Crystal Structure and Refractive Index," Professor W. L. Bragg (son of the President) said that when an electromagnetic wave passed through a medium the electric field polarised the atoms and displaced their positive and negative components, creating an internal field equivalent to an electric doublet around each atom. The atom would be affected by the general field and its polarised neighbours. The latter effect could be calculated by X-ray analysis, and by these and optical arguments the double refraction of the two crystal forms of calcium carbonate, the rhombic calcite and the monoclinic aragonite, could quantitatively be explained. In both crystals the atoms of Ca and CO_3 molecules (with the carbon in the centre of the oxygen atoms) were lying in parallel planes, at right angles to the trigonal axis in calcite and to the pseudo-hexagonal axis in aragonite. The light waves polarised the oxygen atoms more than the others, and the mutual action of the oxygen atoms upon one another depended upon their spacings, as Professor Bragg exemplified with the aid of models of three magnetic needles, placed either horizontally or vertically. The spacings determined by X-ray measurements and the refractive data were in close accord. Similar considerations should, and did, apply to sodium nitrate, and should apply also to gases, and the planes of polarisation could likewise be deduced.

Professor Bragg subsequently exhibited models of these crystals, explaining that each atom took up a certain space, which was larger for chlorine than for potassium, and larger for manganese than for iron. Hence the axial ratios (the rhombohedral angles) of the crystals of carbonates should vary indirectly as the molecular volume; this seemed to hold for the carbonates of magnesium, zinc, manganese, &c., calcium; the molecular volume increased in that order from 27 to 36, whilst the angle decreased from 103·5 deg. to 101·9 deg. The argument was based upon calculations of the electrostatic potential energy per gram-molecule, assuming that the rhombohedrons of different crystals were elongated or shortened by the introduction of different metals. These calculations formed the subject of a further paper by Professor S. Chapman, F.R.S., and Professor Bragg on "Theoretical Calculations of the Rhombohedral angle of Calcite Crystals."

Dr. G. Shearer's contribution on "The Chemical and Physical Significance of X-Ray Measurements of Compounds containing Long Chains of Carbon Atoms" gave the result of researches by himself and Dr. Alexander Müller, conducted under Sir William Bragg and partly noticed by us in connection with Sir W. Bragg's recent Royal Institution lectures. As the number of carbon atoms (the CH_2 groups of paraffin bodies) increased, Dr. Shearer showed the length of the molecules also increased, and certain X-ray doublets, lines, &c., approached one another more closely; that straight line relation, Dr. Müller added, broke down, however, as the number of carbon atoms (more than 30 in some cases) fell to four and less. The regularity showed that the successive carbon atoms were linked at the tetrahedral angle, and indicated a marked directive property of the valency bond in carbon. The new work described on ketones and double bonds in various parts of the chains (centre or end) was of considerable chemical interest.

The paper, by Mr. S. H. Piper, of Bristol, on "X-Ray Measurements as an Aid to Chemical Research," was of a similar character, and also of practical interest. Normally hydrocarbon paraffins are not supposed to oxidise on distillation; some waxes which Mr. Piper distilled did oxidise, and the X-ray measurements did not agree with the ordinary molecular weight determinations and suggested that some of these hydrocarbons were not normal, but contained side chains. The paper on "The Determination of Molecular Symmetry in Crystals and its Possibilities as a Method of Deriving Structural Formulæ," by Mr. W. T. Astbury (Royal Institution), dealt with the general help which X-ray measurements give in making a choice of several possible formulæ, and in particular with the isotrimorphism of the tervalent metallic acetyl-acetones (of aluminium, chromium, gallium, iron, &c.).

The paper of Professor C. H. Desch, F.R.S., on "Crystal Surface," was of a different kind. Whilst the atoms in the interior of crystals were held in position by symmetrical forces, he remarked that symmetry disappeared at the surface and the difference partly manifested itself as surface tension. When the temperature was raised, cohesion and surface tension decreased, but not necessarily at the same rate. High temperature, though hundreds of degrees below the melting point, might deform crystals somewhat as did cold work, and might round off the sharp angles. Hexagonal crystals of gold (melting point 1,062 deg. C.) began to crumple with prolonged heating to 600 deg., and changed into globules at 900 deg. Slowly-cooled gold beads might form a single crystal, which behaved and looked as if they were provided with a skin of gelatine. When this skin was etched off the crystalline structure underneath it became visible, but was lost again by heating; a removal of a layer of 0·62 $\mu\mu$ thickness brought out the first appearance of roughness. Similar results were obtained with silver, which was not so pure and not so suitable as gold, however, whilst tin (melting point, 232 deg. C.), of a metal of lower surface tension, retained its crystalline sharpness at 213 deg.

On behalf of Mr. J. E. Jones, of Cambridge, Mr. R. H. Fowler presented a paper on the "Crystal Structure of Solid Argon," dealing with the correlation of the forces acting between the atoms of an element in the gaseous and in the solid states. Mr. Jones had made use of the equation of state of Kamerlingh Onnes, $pv = RT + B/v$, where B was an experimentally-determinable temperature function, which could also be calculated given the laws of force between the atoms. According to Simon and Simson the crystal form of solid argon was face-centred cubic, and the distance between adjacent atoms was $3{\cdot}84 \times 10^{-8}$ cm.; that agreed with the B calculations. Moreover, the crystals of potassium chloride and calcium sulphide had similar structures, and the agreement between measurements and calculations was close in these cases.

In the general discussion, Dr. A. W. Hull referred to the structure of graphite, mentioning measurements made on a natural crystal, as to which he agreed with Sir W. Bragg, but not with Debije and Scherrer. Professor L. C. Graton, of Harvard College, raised another point. He suggested that changes in minerals were due rather to diffusion of solutions than to flow phenomenon. Diffusion allowed of interaction in opposite directions. When biotite gradually changed into muscovite (two kinds of mica) the latter formed an inceasing shell of pure muscovite round a decreasing core of biotite; potassium had passed inward, iron and magnesium outward; it was not a question of leak, and the space lattices would have to permit of the migration of ions. Was that confirmed by measurement, and were the lattice spacings sufficiently open to permit foreign ions to pass without colliding? Further, would the forces at play vanish at absolute zero?

Atomic Disintegration.

Sir Ernest Rutherford's discourse on "Atomic Disintegration," delivered on the Tuesday afternoon, was a summary of the remarkable researches by himself and his collaborators, with which we dealt last on pages 458 and 459 of our issue of April 11.

We regret to have to limit ourselves on this occasion to his most recent work, showing that hydrogen nuclei (protons) could be ejected from the nuclei of more than the six elements of odd atomic numbers (boron 5, nitrogen 7 fluorine 9, sodium 11, aluminium 13, phosphorus 15), which had at first seemed to stand apart. To get at close ranges at slow speed, essential for the light elements, Sir Ernest stated, Dr. Chadwick had so arranged the apparatus that the vertical rays fell at 45 deg. on the substance (a film or plate); any primary hydrogen particles present (most difficult to eliminate) would then escape at very short ranges (because ejected by collisions at right angles), and would not disturb the observations. They then found that oxygen gave no protons; neon gave some of 16 cm. range, silicon of 20 to 30 cm., sulphur of 20 to 30 cm., chlorine (uncertain before) and argon also, of 20 to 30 cm., and potassium of 17 to 25 cm. Pure iron had given protons, but they had vanished on heating, which expelled nitrogen.

Thus oxygen (atomic weight 16 = 4 times helium) could not be disintegrated, but sulphur (atomic weight 32) could be and should, therefore, contain protons in addition to helium nuclei. The radio-active elements, on the other hand, seemed to be free of protons. Carbon had given no particles either; Petterson claimed to have obtained some, but this work was full of pitfalls. Some atoms of even atomic numbers had been disintegrated, but those of odd numbers seemed in general to be much more liable to disintegration, and that was in accord with the striking relative predominance in our Earth of elements of even numbers. The forces involved in these bombardments by α particles were of the order of four million volts; ordinary speeds of thousands of volts could do nothing. There appeared to be no other way of attacking these problems, except by the study of γ-rays which Dr. Ellis and others on the Continent had taken up successfully. Sir Ernest concluded with the remark that they had achieved much that he had, still in 1913, thought must be left for the next generation to deal with.

(To be continued.)

* See page 349, *ante*.

THE FÖTTINGER CLUTCHES OF THE MOTOR-SHIP "VULCAN."

IN the issue of ENGINEERING of July 18, pages 92 to 94, a full description, with illustrations, was given of the complete single-screw geared Diesel machinery of the motor-ship Vulcan, built by the Vulcan Werke of Hamburg and Stettin. In connection with this installation further information has now come to hand as to the efficiency of the oil-filled Föttinger clutches, which no doubt will be of considerable interest.

The diagrams in Fig. 1 show the torsional oscillations in the Diesel engine shaft of the Vulcan's engines (T_1 and T_2) as compared with those in the shafting abaft the oil clutches (T_3 and T_4) obtained in recent tests. The power of the engine for these special tests in the makers' works was absorbed, as shown in

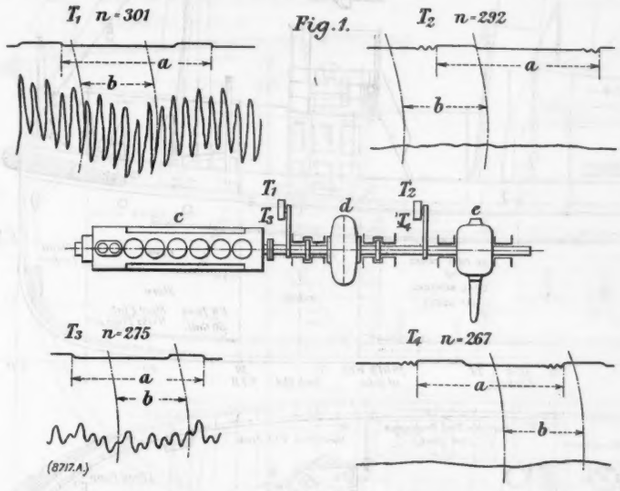


Fig. 1.

Fig. 1, by a water brake e. This particular submarine type of oil engine had a very bad period of crankshaft torsional oscillations at a speed of revolution of 301 r.p.m., and similar vibrations of considerably lesser amplitude at 275 r.p.m. At all four speeds used, 301, 292, 275 and 267 r.p.m., all the torsional vibrations of the engine shaft were damped out by the oil in the Föttinger clutch as shown by the graphs. The positions in which the recording instruments were located is clearly indicated in the illustration. The distance *a* in the diagram represents 0·4 second, and the distance *b* is one revolution of the Diesel engine. These diagrams serve to prove the efficiency of this clutch in damping out torsional vibrations.

A number of further experiments have very recently been carried out in the makers' works with a clutch of greater size and power than those fitted to the machinery of the motor-ship Vulcan. This was a unit nominally rated at 2,000 brake horse-power and of 2,200 mm. diameter, and the results have been compared with those of the earlier clutch of 1,400 mm. diameter. The results of these experiments are given in Fig. 2. The plant on which they were tried out comprised a standard steam turbine driving through reduction gear and through a Föttinger clutch on to a water brake. The curves given in Fig. 2 indicate the relation for both sizes between a design constant and the slip, *i.e.*, the ratio of the speed of revolution of the driven and the driving shafts. Torsionmeters in the experimental plant were placed one on each side of the Föttinger clutch. The percentage slip is a direct and proportional index of the efficiency. This diagram shows that with the larger diameter clutch, the efficiency is considerably higher than with the smaller, and therefore can be varied according to the dimensions of clutch which may be decided upon. Taking a designed constant figure of 3, and assuming the oil temperature to be 45 deg. C., the slip, with the larger clutch, will be 4½ per cent. or the efficiency 95½ per cent., whereas with the smaller clutch the slip would be more than 6 per cent. with an efficiency of approximately 94 per cent., when transmitting the same power. This increase in

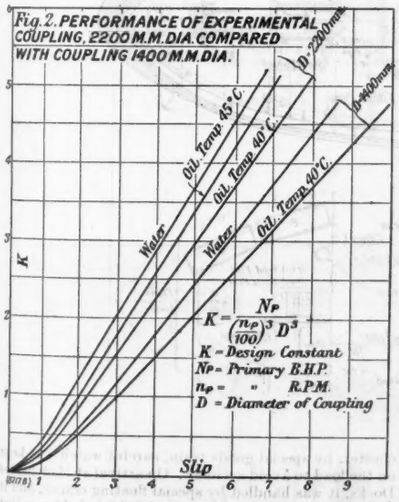


Fig. 2. PERFORMANCE OF EXPERIMENTAL COUPLING, 2200 M.M. DIA. COMPARED WITH COUPLING 1400 M.M. DIA.

efficiency is probably due to the larger number of vanes with which the larger coupling is fitted.

From the curves in the diagram, Fig. 2, it will be seen, for instance, that with a slip of 3 per cent. or an efficiency of 97 per cent., the larger coupling would transmit 1·6 times the horse-power of the smaller. In other words, assuming, in the case of the smaller coupling, that 285 h.p. is transmitted at 300 revolutions, a constant of 1 with oil at a temperature of 40 deg. C. will correspond to a slip of 3 per cent., or an overall efficiency of 97 per cent.: whereas the larger coupling will transmit 800 h.p. at 250 revolutions per minute, and, as is shown in Fig. 2, with only a slip of 2·2 per cent. or an efficiency of 97·8 per cent. Alternatively, of course, a smaller coupling than that of 2,200 mm. diameter might be used for the transmission of the higher horse-power, namely, 800 h.p., to give the same efficiency, namely, 97 per cent., as the smaller coupling of 1,400 mm. when it transmits 285 brake horse-power. Water can be used, as shown, with a slight gain in efficiency, although, for reasons of expediency and the elimination of corrosion, oil will doubtless be generally preferred. The manner in which, therefore, the foregoing efficiencies can be gained, or a compromise can be made, will be clear from the results of these trials. They show definitely such a remarkably high overall power transmission efficiency for these clutches that any loss of power in the coupling should be no deterrent to their successful application.

THE MOTORSHIP "BRITISH AVIATOR."

To Messrs. Palmer's Shipbuilding and Iron Company, Limited, of Jarrow-on-Tyne, is to be given the distinction of having completed and delivered the highest-powered single-screw motorship to date. The British Aviator is an oil-tanker with a deadweight capacity of 10,200 tons, which was recently built for the British Tanker Company, Limited. It is driven by a Diesel engine of 3,000 b.h.p. The principal dimensions of the vessel are: Length between perpendiculars, 440 ft.; breadth extreme, 57 ft.; depth to upper deck, 33 ft. 11 in., and it is classed 100 A.1. at Lloyds. This vessel is of the two-deck type, with poop, bridge and forecastle, and has been built on the longitudinal system of framing. The arrangements for the officers and crew and the whole of the accommodation on this ship are of elegant and comfortable design and finish. Very successful sea trials were recently carried out. A large number of visitors attended, and interest naturally centred in the large Camellaird-Fullagar engine which is the main propelling unit. This engine was very fully described and illustrated in ENGINEERING of August 31, 1923; further details of test results were published by us on March 28, 1924, and interesting improvements to facilitate dismantling and overhauling were described in our columns on July 25.

It might be restated that the main engine has six working cylinders of 23 in. diameter, and the pistons have each a stroke of 36 in. The combined stroke of the two pistons in each cylinder is 72 in. At a maximum speed of revolutions of 90 r.p.m., the piston speed is the very moderate figure of 540 ft. per minute. During sea trials a maximum speed of 11·7 knots was attained, when the engines developed 2,950 b.h.p. (3,720 i.h.p.) and the propeller speed was 82·5 r.p.m. This result was obtained when using Anglo-Persian Diesel oil of 18,900 B.Th.U. calorific value. At 1,920 b.h.p. and 72·8 r.p.m. the speed was 10·58 knots.

Throughout the trials the main engines ran steadily and without vibration. Experiments are now being conducted in connection with the air inlet valves to the square section scavenging pumps, which, as is normal with this type of engine, are placed above the main cylinders. The pistons of these scavenging pumps form the crossheads, which take the side thrust of the upper pistons. The air being drawn into these pumps caused a certain amount of noise, which doubtless can be eliminated when the best combination of valve and port area and form are found. Manœuvring trials were carried out and demonstrated the ease of handling of the engine by one operator. With the ship having full way on ahead the engine was put full astern successfully and a large number of orders were rapidly carried out.

The displacement of the British Aviator is 14,590 tons and the cargo is carried in 10 main oil tanks. For dealing with the oil cargo two steam-driven Hayward-Tyler pumps are fitted in a pump-room amidships. Each of these pumps has a capacity of 325 tons per hour. There are also steam-driven ballast and fuel-oil transfer pumps placed forward. Many of the auxiliaries of the ship are steam driven and are supplied from two Scotch boilers of 11 ft. 6 in. diameter and 11 ft. 6 in. length, and provided with two furnaces. They are installed on the stiffened upper deck forward of the main engine and work at 150 lb. per square inch pressure. Both have oil-firing gear and one is also fitted to take the exhaust gases from the main engine. Apart from the Weir feed pump for the boilers and the oil-firing gear, the principal steam auxiliaries in the engine-room are a steam-driven air compressor, made by Messrs. G. and J. Weir, Limited, fire, bilge and ballast pumps, an auxiliary condenser, a 15-ton evaporator and a 25-ton water distilling plant. The steam-driven air compressor is of a capacity sufficient to deal with 450 cub. ft. of free air per minute, and delivers at a pressure of 1,000 lb. per square inch. This large auxiliary has ample capacity to meet all the requirements of heavy manœuvring. All the oil for fuel injection and starting is stored in bottles at this maximum pressure. Air-control valves for all the services are conveniently grouped on a control board beside the operator at the starting platform of the main engine.

The auxiliaries normally required at sea, including the steering gear, are electrically driven, power being developed by two Polar four-stroke cycle two-cylinder Diesel engines of 90 brake horse-power, driving Metropolitan-Vickers dynamos at 300 r.p.m. These are extremely interesting sets. The injection air compressors for these auxiliary engines are driven by beam levers from one of the engine gudgeon pins. The electric power developed is utilised to drive the motors of oil-transfer, sanitary, bilge and general service pumps, as well as a stand-by forced-lubrication pump and a pump for circulating the oil and fresh cooling water in an oil cooler. An electrically-driven oil purifier is also installed. By means of links and levers from the main engine compressor crosshead, the drive is obtained for three pumps for combined piston and cylinder fresh-water cooling, salt-water circulation of the compressor and guides and forced lubrication to all the main bearings. It is expected that sufficient steam will be raised in the one Scotch boiler capable of being exhaust-gas fired, to perform any duties, at sea demanding steam.

The lay-out of the machinery, especially observing that it is placed aft, is excellent. Good passage ways are provided and a very considerable area of floor space, useful in the event of overhaul of the main machinery, &c., is available abaft the main engine in way of the main Michell thrust block. The thrust shaft has two collars, so that in the event of damage to one the shaft can be turned end for end.

The British Aviator sailed on her maiden voyage to Abadan on August 13, after completing her trials by the Marine Oil Engine Committee. On the continuous run to Port Said from the Tyne the following results were obtained by the owners: i.h.p. 3,115, s.h.p. 2,492; revolutions per minute, 74; consumption of Anglo-Persian oil (of 18,900 British Thermal units per pound) 9·02 tons per day for all purposes. The consumption of oil fuel is equivalent to 0·28 lbs. per indicated

STEEL SCREW TUG AND WATER-BOAT "LORD COMBERMERE."

CONSTRUCTED BY MESSRS. J. SAMUEL WHITE AND CO., ENGINEERS AND SHIPBUILDERS, COWES.

Fig. 1.

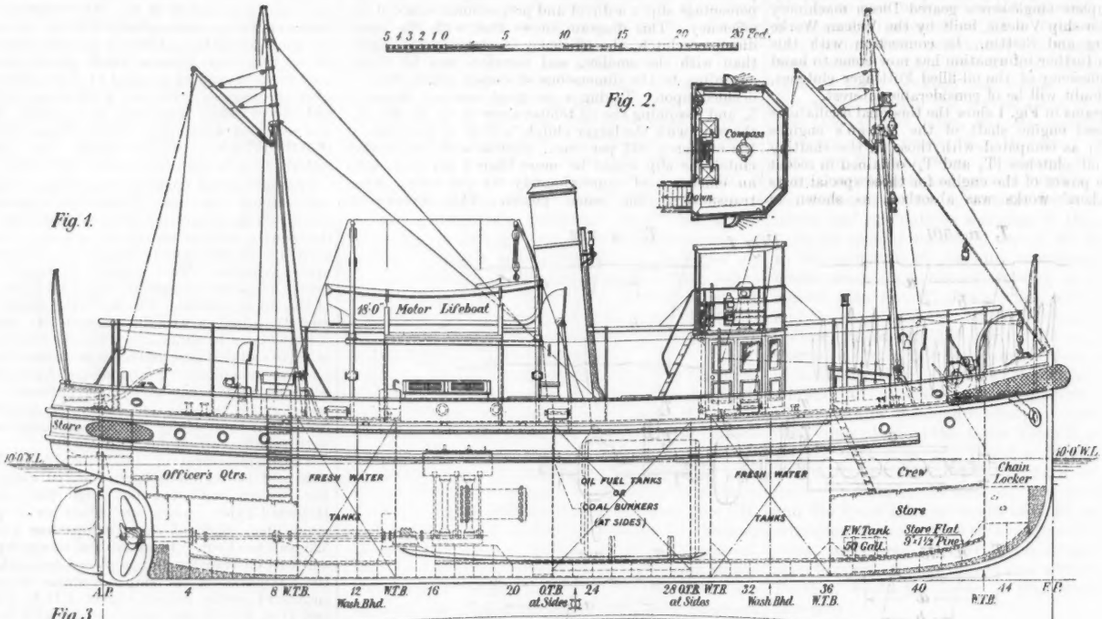

5 4 3 2 1 0 5 10 15 20 25 Feet.
18'0" Motor Lifeboat
Store
10'0"W.L.
Officer's Qtrs.
FRESH WATER TANKS
OIL FUEL TANKS OR COAL BUNKERS (AT SIDES)
FRESH WATER TANKS
Crew
Store
Chain Locker
F.W.Tank 50 Gall.
Store Flat 9"x1½" Pine
A.P. 4 8 W.T.B. 12 W.T.B. Wash Bhd. 16 20 O.T.B. at Sides 24 28 O.T.B. W.T.B. at Sides 32 Wash Bhd. 36 W.T.B. 40 44 W.T.B. F.P.

Fig. 2.

Fig. 3.

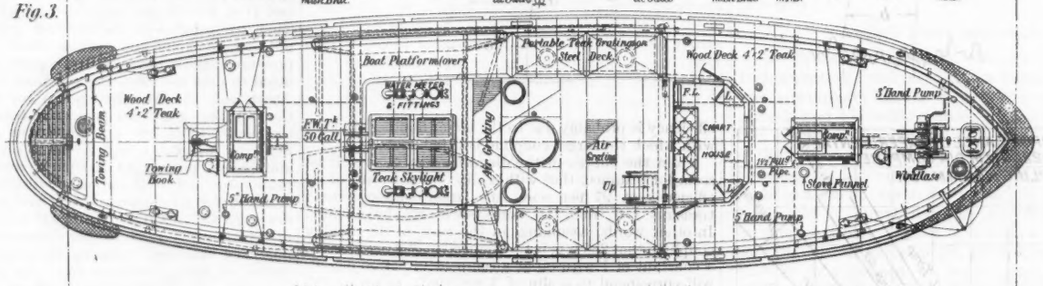
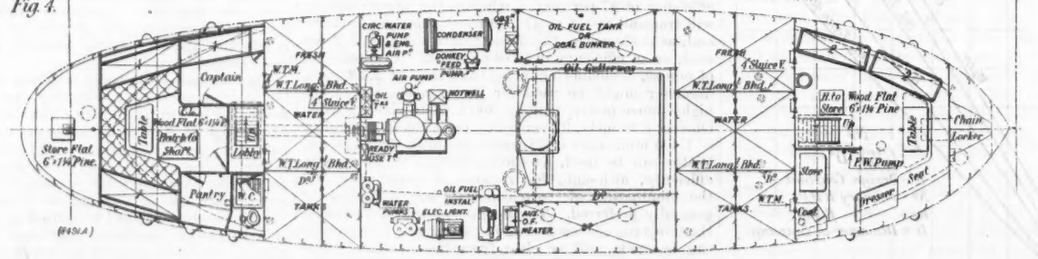


Fig. 4.



horse-power per hour, or 0·35 lbs. per shaft horse-power per hour. The de Laval centrifugal oil separator was in continuous use throughout the voyage, which was completed at an average speed of 11·31 knots.

THE TRANSPORT OF LARGE ELECTRICAL PLANT.

THE art of handling materials has made very rapid strides within the last few years, so much so that it might almost be said that the problem of moving a certain mass of a given material from one situation to another can be solved by consulting a curve or two on a suitable chart. But a problem far beyond this method of treatment was that involved in the recent transport of a turbo-alternator stator from the Witton Works of the General Electric Company, Limited, to the hold of the ss. Clan Mackellar, which is taking the stator from Manchester Docks to Sydney Harbour. The turbo-alternator referred to is for Sydney Municipality, and has an output of 16,000 Kv.-a., at a pressure of 5,400 volts, when running at a speed of 3,000 r.p.m. When it is realised that the power generated is in excess of 20,000 h.p., an idea of the weight and dimensions of the machine may be gained.

The stator weighs 50 tons, and has overall dimensions of 12 ft. 9 in. in length, 9 ft. 10 in. in height, and 10 ft. 7 in. in breadth. Powerful overhead travelling cranes solved the initial stage of the problem of moving the stator within the works, but the real difficulties began when the operation of transporting it to the railway siding. Although the distance was short, nearly five hours were occupied in performing the journey, due to the necessity for avoiding all risk of the wheels of the lorry, on which the stator was carried, sinking into the roadway and possibly damaging the various service mains below. To prevent this, steel plates were laid beneath the lorry wheels along this entire section of the journey.

The continual relaying of this emergency metal track was the primary cause of this part of the operation taking so long.

The transfer of the stator from the lorry to a railway truck was the next difficulty. Two of the largest cranes of the L.M. & S. Railway Company were utilised, these being specially sent down from Crewe for the purpose.

The truck used to carry the stator was of the double bogie pattern, built at the L.M. & S. Railway Wagon Works, Newton Heath.

The lowering of the stator on to this truck was performed with a view to secure perfect balance and distribution of weight. During the journey to Manchester, by special goods train, careful watch was kept on the load to avoid accident. On arrival at Manchester Docks, it was handled by special floating cranes, and it was noted that the entrance to the ship's hold was just sufficiently large to admit the stator.

The safe transport of such a huge piece of apparatus must be warmly commended.

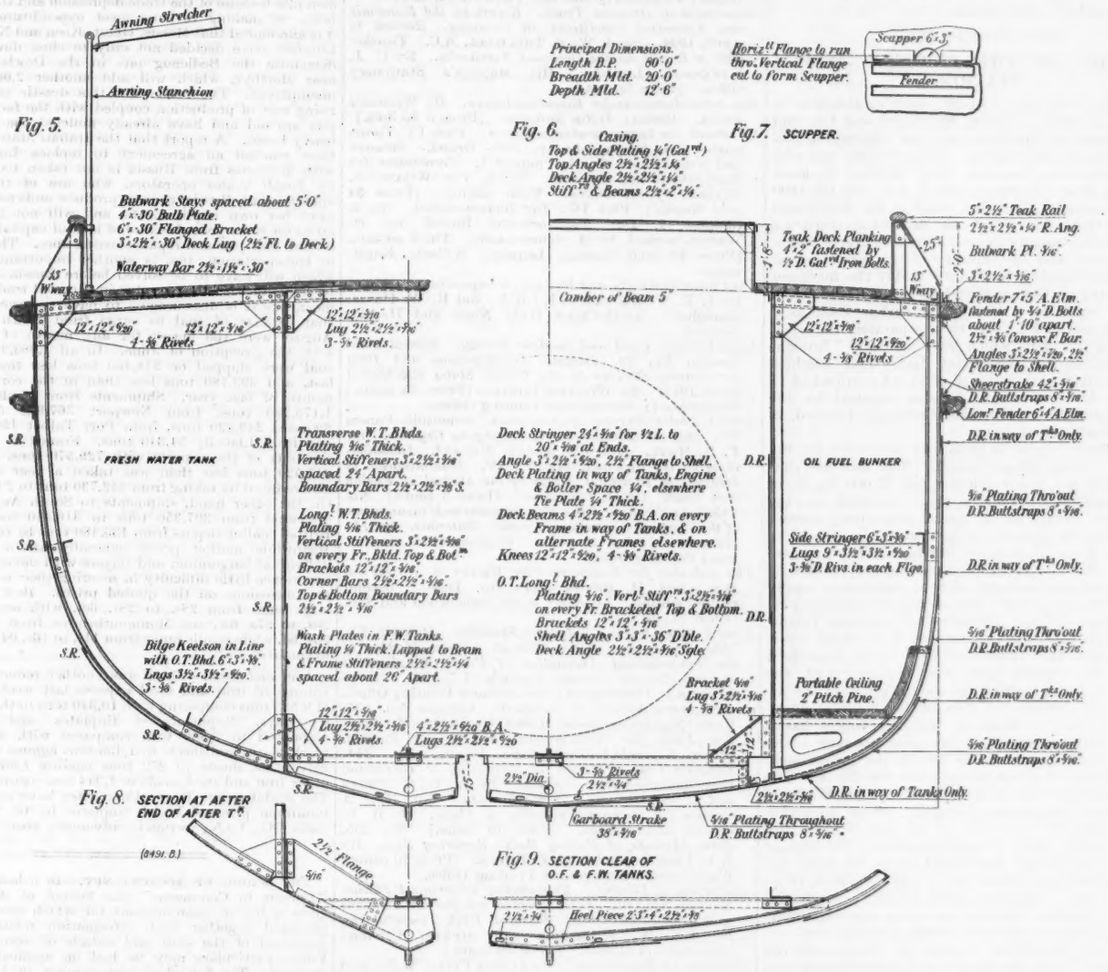
STEEL SCREW TUG AND WATER-BOAT "LORD COMBERMERE."

THE illustrations on this and the opposite page show the general arrangement and details of the Lord Combermere, a sea-going steamer designed and built by Messrs. J. Samuel White and Co., Limited, of Cowes, Isle of Wight, for service as a Tug and water-boat at Barbados. She is primarily intended for conveying water to ocean ships lying in the Bridgeton Roadstead, the outer harbour of Barbados. Built to the order of the Crown Agents for the Colonies under the supervision of Messrs. Flannery, Baggallay and Johnston, Limited, she is of the single-deck type, with straight stem and cruiser type stern, and has the following dimensions:—Length overall, 85 ft.; length between perpendiculars, 80 ft.; breadth moulded, 20 ft.; depth moulded, 12 ft. 6 in.; draft loaded, 10 ft.

As will be seen from the longitudinal section given

STEEL SCREW TUG AND WATER-BOAT "LORD COMBERMERE."

CONSTRUCTED BY MESSRS. J. SAMUEL WHITE AND CO., ENGINEERS AND SHIPBUILDERS, COWES.


Awning Stretcher
Awning Stanchion
Fig. 5.
Principal Dimensions.
Length B.P. 60'0"
Breadth Mld. 20'0"
Depth Mld. 12'6"
Horiz.l Flange to run thro. Vertical Flange cut to form Scupper.
Scupper 6"x3"
Fender
Fig. 6. Casing.
Top & Side Plating ¼"(Cat.ed)
Top Angles 2½"x2½"x⅜"
Deck Angle 2½"x2½"x¼"
Stiff.rs & Beams 2½"x2½"x¼".
Fig. 7. SCUPPER.
Bulwark Stays spaced about 5'0"
4"x·30" Bulb Plate.
6"x·30" Flanged Bracket
3"x2½"x·30" Deck Lug (2½" Fl. to Deck)
Waterway Bar 2½"x1¼"x·30"
Camber of Beam 5"
Teak Deck Planking 4"x2" fastened by ½ D. Cat.ed Iron Bolts.
5"x2½" Teak Rail
2½"x2½"x½" R. Ang.
Bulwark Pl. 5/16".
3"x2½"x5/16".
Fender 7"x5" A. Elm. fastened by ¾ D. Bolts about 1'10" apart.
2½"x⅜" Convex F. Bar.
Angles 3"x2½"x7/20", 2½" Flange to Shell.
Sheerstrake 42"x5/16"
D.R. Buttstraps 8"x5/16".
Lowr Fender 6"x4" A. Elm.
D.R. in way of Tks Only.
5/16" Plating Throut
D.R. Buttstraps 8"x5/16".
Side Stringer 6"x3"x⅜"
Lugs 9"x3½"x3½"x5/16"
3-⅜" D. Rivs. in each Flge.
D.R. in way of Tks Only.
5/16" Plating Throut
D.R. Buttstraps 8"x5/16".
D.R. in way of Tks Only.
5/16" Plating Throut
D.R. Buttstraps 8"x5/16".
D.R. in way of Tanks Only.
5/16" Plating Throughout
D.R. Buttstraps 8"x5/16".
Transverse W.T. Bhds. Plating 5/16" Thick. Vertical Stiffeners 3"x2½"x5/16" spaced 24" Apart. Boundary Bars 2½"x2½"x⅜" S.
Long.l W.T. Bhds. Plating 5/16" Thick. Vertical Stiffeners 3"x2½"x5/16" on every Fr., Bkhd. Top & Bot.m Brackets 12"x12"x5/16". Corner Bars 2½"x2½"x¼". Top & Bottom Boundary Bars 2½"x2½"x5/16"
Wash Plates in F.W. Tanks. Plating ¼ Thick. Lapped to Beam & Frame Stiffeners 2½"x2½"x¼ spaced about 26" Apart.
Deck Stringer 24"x5/16" for ½ L. to 20"x5/16" at Ends.
Angle 3"x2½"x7/20", 2½" Flange to Shell.
Deck Plating in way of Tanks, Engine & Boiler Space ¼", elsewhere Tie Plate ¼" Thick.
Deck Beams 4"x2½"x7/20 B.A. on every Frame in way of Tanks, & on alternate Frames elsewhere.
Knees 12"x12"x7/20", 4-⅞" Rivets.
O.T. Long.l Bhd. Plating 5/16". Vert.l Stiff.rs 3"x2½"x5/16" on every Fr. Bracketed Top & Bottom. Brackets 12"x12"x5/16" Shell Angles 3"x3"x·35" D'ble. Deck Angle 2½"x2½"x5/16 Stgle.
Bilge Keelson in Line with O.T. Bhd. 6"x3"x⅜" Lugs 3½"x3½"x7/20. 3-⅜" Rivets.
Bracket 5/16" Lug 5"x2½"x5/16" 4-⅞" Rivets
Portable Ceiling 2" Pitch Pine.
12"x12"x5/16" Lug 2½"x2½"x5/16" 4-⅞" Rivets
4"x2½"x7/20" B.A. Lugs 2½"x2½"x7/20
3-⅞" Rivets
2½" Dia.
2½"x2½"x¼
Garboard Strake 38"x5/16
Fig. 8. SECTION AT AFTER END OF AFTER Tk
(Stbd. S.)
2½" Flange
5/16
Fig. 9. SECTION CLEAR OF O.F. & F.W. TANKS.
2½"x¾
Heel Piece 2'3"x4"x2½"x⅜"
FRESH WATER TANK
OIL FUEL BUNKER
S.R.
D.R.

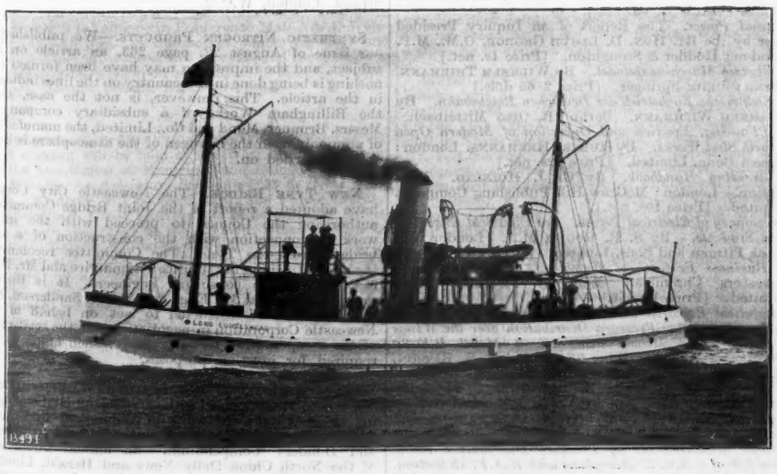


FIG. 10. THE VESSEL ON TRIAL.

in Fig. 1, the vessel is divided by five transverse watertight bulkheads into the following compartments:—Fore peak and chain locker, crew's quarters, fresh-water tank, engine and boiler-room, fresh-water tank and officers' quarters. Each fresh-water tank is sub-divided by two longitudinal bulkheads, which are shown in Figs. 4 and 5. Thwartships wash-plate bulkheads are fitted in each tank. The total water carrying capacity is 105 tons. Two fuel tanks having a capacity of 26 tons of oil fuel or alternatively 21 tons of coal are fitted one on each side of the boiler-room.

The officers' accommodation aft is provided with two sleeping berths and a separate cabin for the captain, pantry, &c., while the crew's quarters forward are provided with four sleeping berths. The vessel is rigged as a fore-and-aft schooner, with two pole masts foresail and fore-and-main topsail. Its general appearance is well shown in Fig. 10. A teak chart-house is fitted forward on the main deck, the navigating bridge, being arranged above a canvas awning, is carried round fore and aft, at the level of which a motor life-boat is mounted, the fittings permitting of launching from either side should this be necessary. The anchor and cables are worked by means of a hand windlass, while hand steering gear is fitted on the navigating bridge and a ship towing hook aft of the mainmast. The vessel is electrically lighted throughout on current supplied by a steam coupled generating set of 2-kw. capacity. A large bow fender and quarter bolster fenders are provided for protection when running alongside vessels.

The propelling machinery which has been constructed and fitted by the builders consists of a set of compound surface condensing engines having cylinders 11 in. and 23 in. diameter by 16 in. stroke, developing 200 i.h.p. at 160 revolutions. The air, feed and bilge pumps are driven off the main engine, which is controlled from the bridge. Steam is supplied at a pressure of 140 lb. per square inch by one single-ended marine type return tube boiler, 9 ft. 6 in. diameter and 9 ft. 6 in. in length, fitted with two furnaces arranged for burning either coal or oil on the low-pressure system of J. Samuel White, of Newcastle. The boiler has 882 sq. ft. of heating surface and 34 sq. ft. grate surface. The auxiliary machinery consists of two vertical duplex water pumps, with cylinders 7½ in. diameter, and pumps 5 in. diameter by 7 in. stroke, of the Mumford type; a donkey feed pump with a 6-in. diameter cylinder and 4-in. diameter 7-in. stroke pump of the Weir type and a circulating Mumford pump.

The vessel prior to her departure for Barbadoes underwent sea trials which gave satisfactory results, the contract speed of eight knots being easily

attained. Specially good ventilation has been ensured, in view of tropical working conditions, in all parts of the vessel by means of extra large cowl ventilators to the engine room and stokehold, with cowls extending above the awning deck. The vessel proceeded to Barbados under her own steam.

EXTENSION OF THE BRIGHTON POWER STATION.

A PUBLIC electricity supply was established in Brighton in 1882 by Messrs. Hammond and Co., and the corporation in the following year obtained a Provisional Order for themselves. As is often the case with public authorities, however, they decided to leave pioneering risks to others, and it was not till 1890 that they installed their first plant at the North-road Power Station. In 1900 it was decided to construct a new station at Southwick, on the eastern arm of Shoreham Harbour, and the capacity of this has been extended from time to time, until to-day the machines have a rated output of 20,000 kw. On page 371 in Fig. 1 we reproduce a view of the turbine room as it now exists and in Fig. 2 we show separately the latest addition to the plant which was "officially" brought into operation on Wednesday last. This machine is rated at 6,000 kw. but will carry an overload of 25 per cent. for two hours. It was supplied by the Metropolitan-Vickers Electrical Company, Limited, of Trafford Park, Manchester.

Three-phase current is generated at 8,000 volts, the periodicity being 50 per second. The machine runs at 3,000 r.p.m. The condenser has 12,000 sq. ft. of cooling surface. Auxiliary plant installed at the same time comprises a gear-driven direct-current turbo-generator constructed by Messrs. W. H. Allen, Sons and Co., Limited, of Bedford. This is represented in Fig. 3. It has a rated capacity of 400 to 500 kw. and has been provided to maintain a supply in times of emergency. The auxiliaries ordinarily in use are steam driven. To the boiler house two Yarrow marine type boilers have been added, of which one is oil-fired and the other coal-fired with Underfeed stokers. Economisers have been dispensed with, the waste heat being utilised instead to pre-heat the air entering the furnace. A view of one boiler is reproduced in Fig. 4. Each of the new boilers has a rated capacity of 40,000 lb. of steam per hour. The designed working pressure is 250 lb. per square inch, and the intended steam temperature 600 deg. F. The oil-burning gear has been supplied by the Wallsend Slipway and Engineering Company, whose apparatus has also been fitted to three of the nine Babcock and Wilcox boilers which are also installed. The storage tanks for the oil will hold 1,000 tons. Oil firing has special advantages when heavy peak loads have to be dealt with. Brighton being largely a residential town, the peaks in the load curve are somewhat more prominent than in industrial towns of similar size.

The old generating station at North-road has been turned into a sub-station and is interlinked with the power station by five trunk feeders each of one-quarter square inch section. The aggregate rated capacity of these five lines is 15,000 kw. There are in addition three smaller sub-stations of which that at Kemp Town is of interest in that it is the only one which is automatic, but can at will be "remote controlled" by pilot wires from the main sub-station at North-road. A full description of the Peebles-Reyrolle system of automatic control, which has been adopted here, will be found on page 323 of our last issue.

THE KARRIER LORRY.—The Karrier Motor Company, Limited, of Huddersfield, have recently placed on the market their "J.H." type lorry. Several features of this are of interest. The lorry body is specially constructed with a cab which is narrow to allow of lengths of strip metal being carried along the platform and on the special brackets. The chassis, designed for a load of 3 tons, is fitted with a power unit of 34 h.p., of four cylinders. The cylinders are cast in pairs and have a bore of 110 mm., with a stroke of 140 mm. The valves are of the side-by-side pattern, with forced lubrication. Pump circulation is employed. The cone-type clutch is entirely enclosed, dust proof, easily adjusted and lined with fabric. The machine is fitted with four forward speeds and reverse, the top gear ratio, at 1,000 revolutions, being 7 to 1, corresponding to a speed of 14·7 m.p.h. The rear axle arrangement is interesting. This is driven from the gear-box by a tubular propeller shaft fitted with flexible disc couplings, and is of the worm-driven type with the whole of the gearing mounted in a self-contained member, easily removable from the differential casing. The latter itself, with the sump, is a steel stamping, which makes an extremely strong and reliable construction. Two independent brakes are fitted, one of the external contracting type, acting on the transmission by means of a foot pedal, and the other, of the internal expanding type, operating on drums on the road wheels by means of a hand lever. Solid tyres, 120 mm. by 878 mm., are fitted with twin tyres on the back wheels. The wheel track is 5½ ft. and the wheel-base 14 ft., while the machine itself can completely turn in a 55-ft. circle.

BOOKS RECEIVED.

Department of Overseas Trade. Report on the Economic, Commercial and Industrial Situation of Sweden, March, 1924. By H. KERSHAW, O.B.E. London: His Majesty's Stationery Office. [Price 1*s.* 6*d.* net.]

Department of Overseas Trade. Report on the Economic and Financial Conditions in Germany. Revised to April, 1924. By J. W. F. THELWALL, M.C. *Together with a Report on the Occupied Territories.* By C. J. KAVANAGH. London: His Majesty's Stationery Office. [Price 5*s.* net.]

Die Arbeitsfestigkeit der Eisenbetonbalken. By WILHELM THEIL. Berlin: Julius Springer. [Price 0·55 dols.]

Handbuch der Ingenieurwissenschaften. Part I: *Vorarbeiten und Bauausführung, Erd.- Grund,- Strassen und Tunnelbau.* No. 1, Chapter 1. *Vorarbeiten fur Eisenbahnen und Strassen.* By L. VON WILLMANN. Revised by G. CLAUS. Fifth edition. [Price 34 gold marks.] Part IV: *Die Baumaschinen.* No. 2. Chapter I. *Das Tiefbohrwesen.* Edited by H. WEIHE, revised by A. Schwemann. Third edition. [Price 10 gold marks.] Leipzig: Wilhelm Engelmann.

The China Architects, and Builders, Compendium. Edited by J. T. W. BROOKE, A.R.I.B.A., and R. W. DAVIS. Shanghai: North-China Daily News and Herald, Limited.

United States Coast and Geodetic Survey. Special Publication No. 99. *Isostatic Investigations and Data for Gravity Stations in the United States Established since* 1915. By WILLIAM BOWIE. [Price 25 cents.] Washington: Government Printing Office.

United States Bureau of Standards. Scientific Papers No. 482. *Gravitational Anisotrophy in Crystals.* By P. R. HEYL. [Price 10 cents.] No. 483. *Investigations on the Platinum Metals.* IV. *Determination of Iridium in Platinum Alloys by the Method of Fusion with Lead.* By R. GILCHRIST. [Price 5 cents.] No. 485. *Application of the Interferometer to Measurements of the Thermal Dilatation of Ceramic Materials.* By J. E. MERRITT. [Price 5 cents.] Washington: Government Printing Office.

The Calculus for Engineers. By EWART S. ANDREWS, B.Sc. and H. BRYON HEYWOOD, D.Sc. Second revised edition. London: Scott, Greenwood and Son. [Price 7*s.* 6*d.* net.]

United States Bureau of Labour Statistics. Bulletin No. 355. *Proceedings of the Eleventh Annual Meeting of the International Association of Public Employment Services, Toronto, Canada, September* 4-7, 1923. [Price 10 cents.] Washington: Government Printing Office.

United States Bureau of Standards. Circular No. 155. *United States Government Master Specification for Coal-Tar Pitch for Waterproofing and Damp Roofing.* [Price 5 cents.] Technologic Papers, No. 254. *Emissive Tests of Paints for Decreasing or Increasing Heat Radiation from Surfaces.* By W. W. COBLENTZ and C. W. HUGHES. [Price 5 cents.] No. 255. *A Camera for Studying Projectiles in Flight.* By H. L. CURTIS and OTHERS. [Price 10 cents.] No. 256. *Some Methods of Testing Radio Receiving Sets.* By J. L. PRESTON and L. C. F. HORLE. [Price 10 cents.] Washington: Government Printing Office.

University of Illinois. Engineering Experiment Station Bulletin No. 140. *The Viscosities and Surface Tensions of the Soda-Lime-Silica Glasses at High Temperatures.* By Ed. W. WASHBURN and OTHERS. Urbana: University of Illinois. [Price 40 cents.]

Vibration in Engineering. By JULIUS FEITH, M.Sc., and FREDK. BUCKINGHAM, B.Sc. London: Macdonald & Evans. [Price 7*s.* 6*d.* net.]

Coal and Power. The Report of an Inquiry Presided over by the RT. HON. D. LLOYD GEORGE, O.M., M.P. London: Hodder & Stoughton. [Price 1*s.* net.]

Der Ubersee-Maschinenhandel. By WILHELM THIEMANN. Berlin: Julius Springer. [Price 2·65 dols.]

Der Elektrische Zugbetrieb der Deutschen Reichsbahn. By WILHELM WICHMANN. Berlin: R. Otto Mittelbach.

The Planning, Erection and Operation of Modern Open Hearth Steel Works. By HUBERT HERMANNS. London: Ernest Benn, Limited. [Price 42*s.* net.]

Arc Welding Handbook. By C. J. HOLSLAG. First edition. London: McGraw-Hill Publishing Company, Limited. [Price 10*s.* net.]

A Dictionary of Electrical Terms. For Electrical Engineers and Students. By S. R. ROGET, M.A. London: Sir Isaac Pitman and Sons, Limited. [Price 7*s.* 6*d.* net.]

The Business Features of Wembley. Compiled by the Investors Chronicle. London: Fleetway Press, Limited. [Price 1*s.* net.]

Aeronautical Research Committee. Reports and Memoranda. No. 891. *Pressure Distribution over the Wings of, and Force Measurements on, a Model B.E.* 2c *Biplane, with Raked Wing Tips.* By A. S. BATSON, B.Sc., and H. L. NIXON. [Price 2*s.* net.] No. 894. *Full Scale and Model Measurements of Pressure Distribution Round Two Ribs of a B.E.* 2e *Aeroplane with R.A.F.* 19 *Section.* By A. C. KERMODE and OTHERS. [Price 1*s.* net.] No. 895. *Full Scale and Model Measurements of Pressure Distribution round One Rib of a B.E.* 2c *Aeroplane with R.A.F.* 15 *Section.* By A. C. KERMODE and OTHERS. [Price 1*s.* 6*d.* net.] London: His Majesty's Stationery Office.

THE ROYAL SANITARY INSTITUTE.—The syllabus for the autumn term contains a programme of the courses of lectures and demonstrations to be given at the Royal Sanitary Institute, 90, Buckingham Palace-road, S.W.1, has now been issued. Notification of dates and centres for forthcoming examinations are included, and any further information may be had on application to the Secretary of the Institute, Mr. E. White Wallis.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Conditions in the Welsh coal trade have gone from bad to worse. Already half a dozen collieries have been shut down, rendering some 20,000 men idle because of the trade depression and the impossibility of making revenue meet expenditure. To-day it is announced that Messrs. Guest, Keen and Nettlefolds, Limited, have decided not only to close down but to dismantle the Bedlenog pits in the Dowlais district near Merthyr, which will add another 2,000 to the unemployed. The reason for this drastic step is the rising cost of production coupled with the fact that the pits are old and have already mulcted the owners in heavy losses. A report that the Italian State Railways have reached an agreement to replace English coal with deliveries from Russia is not taken too seriously by South Wales operators, who are of the general opinion that Russia cannot produce sufficient coal to meet her own requirements, and will not be able to do so for some years because of lack of capital necessary to sink new pits and repair existing ones. The question of transportation, too, is another important difficulty which will have to be solved before Russia can expect to compete with this country in the coal trade. In the meantime it is discouraging to have to record the fact that exports of coal as cargo from South Wales in August were the lowest for any month of the year, with the exception of June. In all 1,983,330 tons of coal were shipped or 318,460 tons less than in July last, and 393,180 tons less than in the corresponding month of last year. Shipments from Cardiff totalled 1,175,280 tons, from Newport 367,920 tons, from Swansea 249,430 tons, from Port Talbot 156,370 tons, and from Llanelly 34,340 tons. France as usual took the bulk of the exports with 729,570 tons, which was 217,520 tons less than was taken a year ago. Italy also reduced its taking from 342,730 tons to 299,430 tons. On the other hand, shipments to South America were increased from 307,350 tons to 316,440 tons, and to British coaling depots from 135,480 tons to 161,090 tons. Meanwhile market prices generally are a matter of individual bargaining, and buyers with definite business experience little difficulty in securing their requirements at concessions on the quoted prices. Best Admiralty large rules from 28*s.* to 28*s.* 6*d.*, with seconds from 26*s.* to 27*s.* 6*d.*, and Monmouthshires from 23*s.* 6*d.* to 25*s.* 6*d.* while smalls range from 11*s.* to 16*s.* 6*d.*, according to quality.

Iron and Steel.—There was another reduction in the volume of iron and steel exports last week, the total of 9,533 tons comparing with 10,340 tons in the preceding six days. Shipments of tinplates and ternplates amounted to 5,866 tons compared with 4,856 tons; black plates and sheets to 1,450 tons against 2,930 tons; galvanised sheets to 872 tons against 1,639 tons and other iron and steel goods to 1,344 tons against 915 tons. The Stabilisation (Prices) Committee have increased the minimum price of Welsh tinplates by 6*d.* to 23*s.* 6*d.* basis I.C., f.o.b., owing to advancing costs.

THE SCHOOL OF ACCOUNTANCY.—In a leaflet entitled "Careers in Commerce" the School of Accountancy gives a list of examinations for which candidates are prepared together with information relating to the personnel of the staff and details of evening classes. Fuller particulars may be had on application to the Secretary, The School of Accountancy, 10, Essex-street, Strand, London, W.C. 2.

SYNTHETIC NITROGEN PRODUCTS.—We published in our issue of August 22, page 263, an article on this subject, and the impression may have been formed that nothing is being done in this country on the lines indicated in the article. This, however, is not the case, as at the Billingham Works of a subsidiary company of Messrs. Brunner, Mond and Co., Limited, the manufacture of ammonia from the nitrogen of the atmosphere is being actively carried on.

NEW TYNE BRIDGE.—The Newcastle City Council have adopted a report of the Joint Bridge Committee, authorising the Council to proceed with the initial work in connection with the construction of a new bridge across the Tyne. The Committee recommend the appointment of Sir Maurice Fitzmaurice and Mr. Basil Mott to be the consulting engineers. It is further recommended that Mr. Edge and Messrs. Sanderson, Son and Townend be instructed to act on behalf of the Newcastle Corporation in negotiations for the settlement of the compensation to be given for such lands as are required for erection purposes.

CHINA ARCHITECTS' AND BUILDERS' COMPENDIUM.—Those who are concerned with carrying out civil engineering or constructional work in China will find much helpful information contained in the "China Architects' and Builders' Compendium," an annual publication of the North China Daily News and Herald, Limited, Shanghai, the first edition of which has just been published. The book is intended to be a collection and classification of local information and contains extracts from civil regulations relating to taxes, fire insurance, and land fees, together with water supply, electricity, telephone and gas charges in Shanghai and Hankow. Excellent maps of these districts are supplied, while building rules and data on the costs and properties of materials most commonly used in structures are given. The inclusion of a business directory and a list of advertisements arranged so that descriptive matter relative to similar products, is kept together should assist in ensuring a welcome for the volume.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Evidence continues to accumulate of the abnormal difficulties which steel makers have met, and are still facing, in their endeavour to keep plant operating. One of the largest forge and rolling mills plants in this district reports a loss on the past year of nearly 13,000*l.*, this adverse result being attributed to high cost of production, wages, and fuel, and the ever-increasing burden of Imperial and local taxation. As in other comparable cases output has been disappointingly low and prices most unremunerative. Increased competition is feared from the prospective loans to countries already indebted to us. In other sections of the heavy steel industry conditions seem to be drifting from bad to worse. There appears to be no prospect of a break in the present slump in buying, despite the fact that from the price standpoint circumstances have not been so favourable for renewing stocks at any period during the past 12 months. Orders are confined to small tonnages which for the most part yield no profit, and merely serve to keep machinery operating intermittently and prevent a further spread of unemployment. Sheffield Corporation is evidently preparing for a bad winter. Relief schemes under consideration will call for a total estimated expenditure of nearly half a million pounds, including 60,000*l.* to be spent on road widening, 61,000*l.* on electrical extensions, 100,000*l.* towards the provision of a modern abattoir, and 112,000*l.* in connection with sewage disposal. The execution of these schemes will to a certain extent benefit the local staple industries, as a considerable quantity of machinery and tools will be required. Failure to arrive at a settlement in the basic steel trade dispute is responsible for a big curtailment of output, though the demand, being so greatly restricted, is easily satisfied from alternative sources. Brighter conditions prevail in the lighter sections. An effort has this week been made to assist tool manufacturers to regain overseas trade by exhibiting representative samples of files, hammers, saws, chisels, axes, agricultural requisites, &c., as offered for sale in Shanghai, British North Borneo, South Africa, Batavia, New Zealand and Denmark, by German, Swedish, Japanese, American and Chinese manufacturers.

South Yorkshire Coal Trade.—The stronger tone recently displayed in best quality house coal has resulted in an advance of 1*s.* per ton in leading brands. There is still an abundance of inferior sorts on offer at old rates. Buyers are coming forward more freely, but there is by no means any rush for supplies. Best steams are selling rather better on export account, though the home demand is far from active and quotations are unaltered. Slacks and small coal are somewhat firmer. Quotations:—Best hand-picked branch, 32*s.* to 35*s.*; Barnsley best Silkstone, 26*s.* to 28*s.*; Derbyshire best brights, 26*s.* to 28*s.*; Derbyshire best house, 23*s.* to 25*s.*; Derbyshire best large nuts, 21*s.* to 25*s.*; Derbyshire best small nuts, 15*s.* to 17*s.* 6*d.*; Yorkshire hards, 21*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire hards, 21*s.* to 22*s.*; rough slacks, 12*s.* 6*d.* to 15*s.* 6*d.*; nutty slacks, 12*s.* to 14*s.*; smalls, 6*s.* to 8*s.* 6*d.*

THE CERAMIC SOCIETY.—The fourteenth meeting of the Refractory Material Section of the Ceramic Society will be held in Conference Hall No. 4, at the British Empire Exhibition, on Thursday and Friday, September 18 and 19, when Mr. J. Holland will preside. A Council meeting will be held on Thursday, September 18, in Committee Room "A," Wembley, at 2.30 p.m., while a general meeting will take place in Conference Hall No. 4, Wembley, at 3.15 p.m. A number of papers on clays and other ceramic substances, will be read and those desiring tickets may have them on application to Miss G. Hulme, Central Science School, Stoke-on-Trent.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—A meeting will be held of the West Midland District of the Institution of Municipal and County Engineers, at Malvern, on Saturday, September 13 next, at 11.30 a.m. Members will be received at the Public Library, Graham-road, Great Malvern, at 11.30 a.m., by Dr. H. W. Jacob, Chairman of the Council, when a paper on works in Malvern will be given by Mr. W. Osborne Thorp, engineer and surveyor. After lunch, local works will be inspected, a motor char-a-banc being provided for the party. In order that the necessary arrangements may be made, members intending to be present must give notice to Mr. A. R. Gray, City Engineer's Office, Council House, Birmingham.

PERSONAL.—Messrs. Bates and Windibank, distributors for London and the south of England for Messrs. F. and A. Parkinson, Limited, and Messrs. Flather and Co., Limited, have removed from Sentinel House, Southampton-row, W.C.1, to 140, Southwark-street, London, S.E.1, where larger accommodation is available.—Messrs. Rudge-Whitworth, Limited, Coventry, have now transferred the business and manufacture of their motor wire wheels to their Tyseley Works, Reddingslane, Sparkhill, Birmingham.—Many readers will be interested to know that Mr. James Horne has just retired from active service with Messrs. Vickers Limited. He commenced at the Barrow Factory in August, 1898, as chief hydraulic engineer to the company. Mr. Horne's special work has been the designing of heavy gun mountings and accessory mechanisms, and his brilliant gifts in this direction have won for himself and for Messrs. Vickers Limited, world-wide recognition.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is not a great deal of Cleveland pig iron in stock, for the bulk of the iron lying at makers' yards has been disposed of, but as customers are not lifting their full quantities in fulfilment of purchases, and present demand is not quite sufficient to absorb output, accumulations are, to some extent, being added to, and the position is far from satisfactory. Prices continue to show downward movement though makers are very reluctant to follow the fall. No. 1 is scarce, but small parcels can be bought at 87*s.* 6*d.*, whilst No. 3 g.m.b. is quoted 82*s.* to 82*s.* 6*d.*; No. 4 foundry, 81*s.*; and No. 4 forge, 80*s.*

Hematite.—The East Coast hematite branch is quiet. A few home and export sales have been made, but supply is very plentiful, and prices are weak. Makers are selling Nos. 1, 2 and 3 at 91*s.*; and No. 1 is put at 6*d.* above mixed numbers.

Foreign Ore.—There is very little doing in imported ore. Values are unaltered on the basis of best rubio at 22*s.* c.i.f. Tees.

Blastfurnace Coke.—Durham blastfurnace coke is in only very moderate request, but sellers are markedly disinclined to lower prices, and threaten that rather than do so they will put out ovens. Good medium qualities are obtainable at 25*s.* 6*d.* delivered to local consumers, but some firms hold out for 26*s.*

Manufactured Iron and Steel.—Manufactured iron and steel may be said to be without new feature. Practically all descriptions of material are slow of sale, and fall in prices would cause no surprise. Recognised market quotations stand: Common iron bars, 12*l.* 10*s.*; iron rivets, 14*l.* 5*s.*; packing (parallel), 9*l.*; packing (tapered), 12*l.*; steel billets (soft), 8*l.* 10*s.*; steel billets (medium), 9*l.*; steel billets (hard), 9*l.* 10*s.*; steel boiler plates, 13*l.* 10*s.*; steel ship, bridge and tank plates, 10*l.* 5*s.*; steel angles, 10*l.*; heavy sections of steel rails, 9*l.*; and fish plates, 13*l.*

TENDERS.—We learn that the Direction de l'Outillage du Port, Antwerp, is calling for tenders, to be presented by October 6 next, for the supply and delivery in the Port of Antwerp of a floating grain elevator. Further information may be had on application to the Department of Overseas Trade, 35, Old Queen-street, London, S.W.1, on quoting reference number A.X. 1296.

NORTHAMPTON POLYTECHNIC INSTITUTE.—The handbook "Announcements" of this Institute for the Session 1924–25 has now been issued, and contains full details of the day and evening courses of study offered. Civil, mechanical and electrical engineering, optical engineering and applied optics, horology, automobile engineering, aeronautics, and radio-telegraphy are all included in the scheme of work set out in the book.

SALVAGE OF THE GERMAN SHIPS AT SCAPA FLOW.—We regret that in our article on this subject, in our issue of August 15, page 233, we gave the impression that the work of salvage has been undertaken for the Admiralty. Messrs. Cox and Danks, Limited, inform us that, having purchased a number of the ex-German ships as they lie at the bottom of the sea, they are raising the vessels on their own account. On Friday night last, after a delay of 12 hours owing to bad weather, they were successful in lifting the third destroyer, S. 55, which is now safely in shallow water at Mill Bay, after having been carried by their floating docks and tugs a distance of about 2 miles.

INSTITUTION OF NAVAL ARCHITECTS.—The following scholarships have been awarded by the Council of the Institution of Naval Architects:—Royal Commissioners for the 1851 Exhibition Post Graduate Research Scholarship in Naval Architecture (1924) (250*l.* per annum), to Mr. J. Lockwood Taylor, B.Sc., of Armstrong College, Newcastle-on-Tyne (Durham University). Sir William White Post Graduate Research Scholarship (1924) (150*l.* per annum), to Mr. S. A. Hodges, of the Royal Naval College, Greenwich. Institution of Naval Architects' Scholarship (1924) (130*l.* per annum), to Mr. Leslie Digby, of H.M. Dockyard, Devonport. Earl of Durham Prize, to Mr. F. S. Sutherby, of H.M. Dockyard, Portsmouth.

CONTRACTS.—We learn that the Mirrlees Watson Company, Limited, of Glasgow, have secured an order for three surface condensers, complete with auxiliaries, to be utilised in connection with the electrification of the Capetown Suburban Railways. Each condenser is designed to deal with 104,000 lb. of steam per hour from a 10,000 kw. turbo-alternator set.—The Westinghouse Brake and Saxby Signal Company, Limited, have received an order from the Collins Green Colliery Company, Limited, for electro-pneumatic safety appliances for their No. 1 Bold Pit, comprising two sets of completely interlocked air lock door control gear, tub retarders for the running-off side of pit head, blocks for holding tubs in front of pit head, and point operating cylinders for control of the diverging roads at the running-on side of the pit.—We are informed that Messrs. Joseph Kaye and Sons, Limited, of 93, High Holborn, London, W.C.1, have secured a contract from the Admiralty, for their patent seamless steel serrated valve oilfeeders, fitted with interchangeable spouts.—The Clyde Crane and Engineering Company, Limited, have been successful in securing an important contract for level luffing cranes for the Great Western Railway Company for service at Alexandria Dock, Newport.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Conditions in the steel trade of Scotland are not improving, and signs of any betterment would seem to be as far off as ever. The past week has not brought out much new business, and with the limited demand now prevailing most of the works are very slack. A fair number of inquiries are in circulation, but the foreign competition is so keen that the local makers have much difficulty in securing fresh contracts. Most of the activity is still centred in the black sheet side of the industry, with makers about full up for the remaining months of this year. Prices all round keep firm and without change. The current quotations are as follow: Boiler plates, 13*l.* 10*s.* per ton; ship plates, 10*l.* 5*s.* per ton; sections, 10*l.* per ton; and sheets, $\frac{3}{16}$ in. to $\frac{1}{4}$ in., 12*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—A quiet tone still prevails in the malleable iron trade of the West of Scotland, and makers are not securing very many specifications. The future of the industry is not very bright and, indeed, for that matter, neither is the present, as only hand-to-mouth conditions prevail. The steel re-rolling branch is also quiet, and little buying is being experienced. Prices are unchanged, with "crown" bars at 12*l.* 10*s.* per ton, delivered Glasgow stations.

Scottish Pig-Iron Trade.—No change of any moment has taken place in the Scottish pig-iron trade this week and dullness is general. Home consumers are not placing orders for anything beyond their actual immediate requirements, and in most cases these do not amount to very much, either for hematite or foundry iron. Export parcels are also not easy to pick up and there is no inducement at the present time to increase output; the tendency is in reality all the other way. The current prices are as follow: Hematite, 4*l.* 16*s.* 3*d.* per ton, delivered at the steel works; foundry iron, No. 1, 4*l.* 18*s.* 9*d.* per ton, and No. 3, 4*l.* 13*s.* 9*d.* per ton, both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, September 6, amounted to 1,011 tons. Of this total, 611 tons went overseas and 400 tons went coastwise. During the corresponding week of last year 728 tons went overseas and 86 tons coastwise, making a total shipment of 814 tons.

Clyde Shipbuilding.—A contract for a motorship of 4,600 tons deadweight has lately been secured by Messrs. Barclay, Curle and Co. (Limited), Whiteinch, Glasgow. This vessel, which will have accommodation for 100 passengers, is to the order of Messrs. Burns, Philp and Co. (Limited), of Sydney, N.S.W., and her dimensions are to be 355 ft. in length, 49 ft. in breadth, and 26 ft. in depth. The machinery is to be supplied by Messrs. John G. Kincaid and Co. (Limited), Greenock, and will be of the Harland and Wolff-Burmeister and Wain type.

ACCIDENTS IN SWISS ELECTRIC POWER PLANTS.—The accidents due to electric current that have come under the notice of strong current inspectors of Switzerland, have shown a steady and satisfactory decrease in late years. The figures for the year 1923 are the following (figures in brackets refer to the year 1922): Altogether 58 (65) accidents were reported; they affected 65 (68) persons, 23 (29) fatally. Of these persons 13 (29) were employees of the works concerned; 22 (18) persons were fitters or other members of installation firms; the remaining 30 (21) accidents concerned the general public. Of the fatal cases, 13 (16) were due to high-tension currents, and 10 (13) due to low-tension currents. The number of fatal accidents was 41 in 1920, and the decrease is particularly marked, in the case of the serious accidents.

ADMIRALTY CONTRACT FOR LARGE AUTOMATIC TELEPHONE EXCHANGE.—The Relay Automatic Telephone Company, of Marconi House, has secured, in strict competition, an important contract to supply H.M. Dockyard, Chatham, with a special model 550-line "Relay" automatic telephone installation, and also to supply a 50-line "Relay" exchange for the Army, Navy and Air Force Hospital, Chatham. The work of manufacture has already begun, and it is anticipated that these exchanges will be working shortly. The installations are to replace the existing manual equipment at both places, but a special building is being erected to accommodate the 550-line "Relay" at the dockyard, where a new main and intermediate distributing frame will be installed, also a new manual board to control the 40 trunks to various exchanges. Although two positions will be fitted to the latter, only one operator will be on duty instead of the four at present required to operate the existing manual exchange. No operator will be employed in connection with the hospital installation. Both models are of the latest 32-volt type, the dockyard exchange being on the trunk line principle, and operated by batteries having a capacity of 350 a/h. Sixteen subscribers will have conference facilities on the dockyard exchange, and 50 will have priority of service, while three lines will have priority on the hospital automatic exchange. Two ringing machines will be fitted on the 550-line exchange, one of which will run off the 220-volt mains and the other off the exchange battery. The hospital exchange will be equipped with duplicate ringers, both of which will run off the exchange battery. The dockyard building will be equipped with a motor generator for charging the batteries, and for the hospital exchange the charging will be carried out by resistance from the 220-volt mains.

THE SOUTHWICK POWER STATION OF THE BRIGHTON ELECTRICITY WORKS.

(*For Description, see Page* 372.)

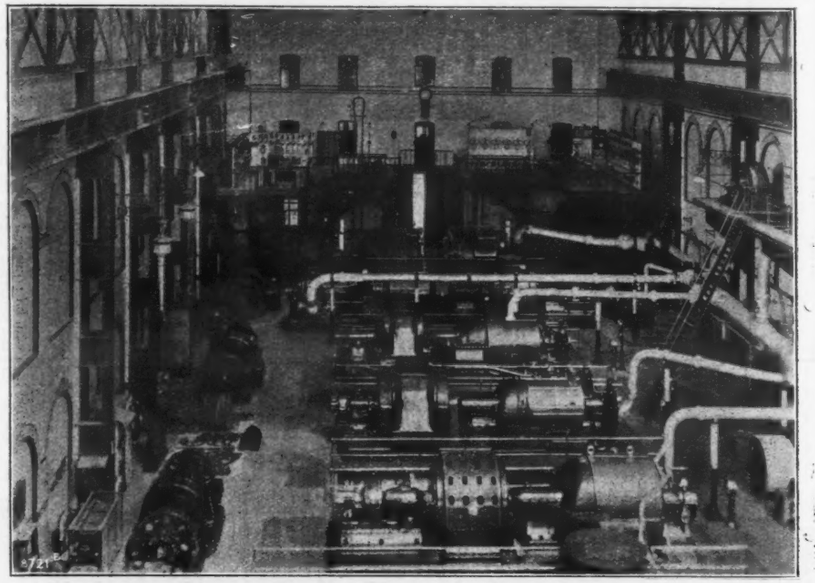


FIG. 1. INTERIOR OF THE BRIGHTON CORPORATION POWER STATION AT SOUTHWICK.

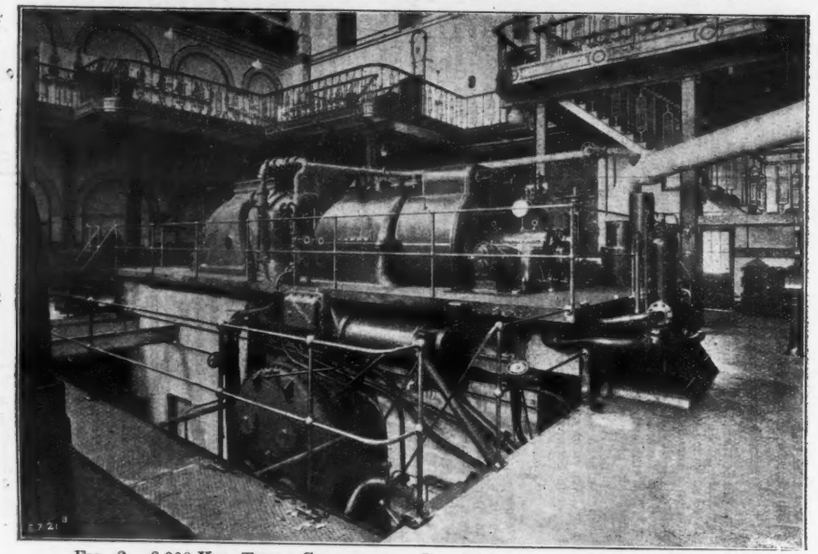


FIG. 2. 6,000-KW. TURBO-GENERATOR; THE METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED.

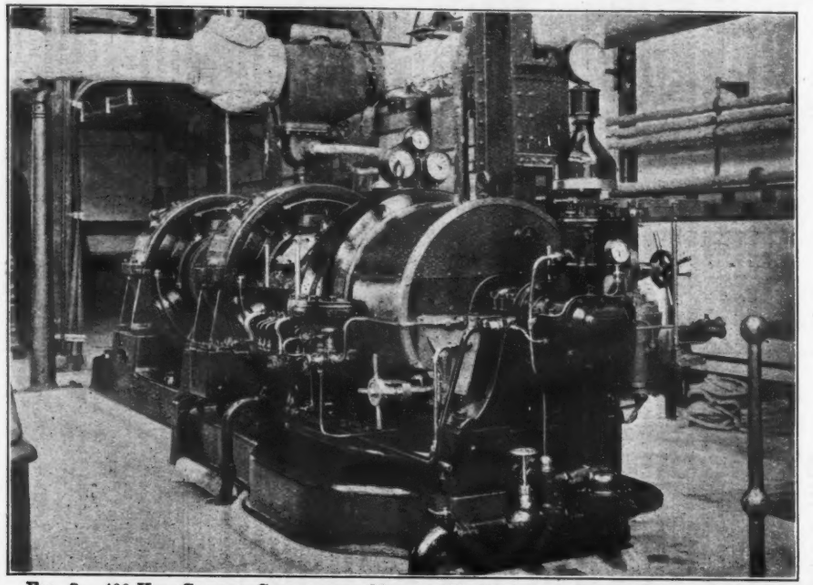


FIG. 3. 400-KW. GEARED GENERATOR; MESSRS. W. H. ALLEN, SONS AND CO., LIMITED.

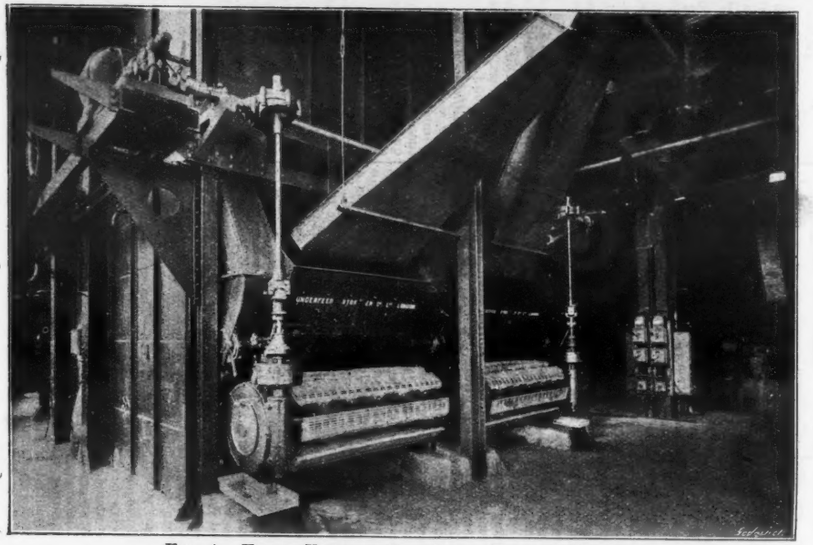


FIG. 4. FRONT VIEW OF COAL-FIRED YARROW BOILER.

LATHES AT THE MACHINE TOOL AND ENGINEERING EXHIBITION

Company, Limited.

LATHES AT THE MACHINE TOOL AND ENGINEERING EXHIBITION.

(*For Description, see Page* 356.)

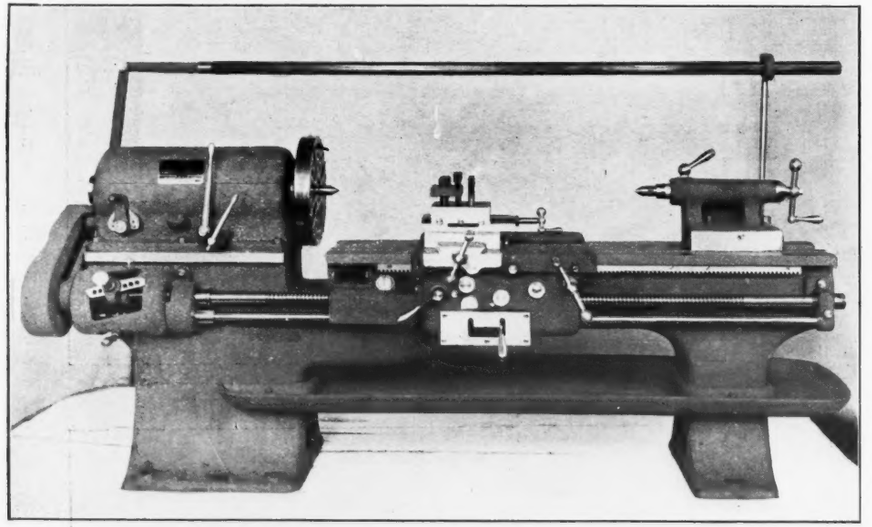


Fig. 72. 7½-In. Centre Geared Head Lathe; The Colchester Lathe Company.

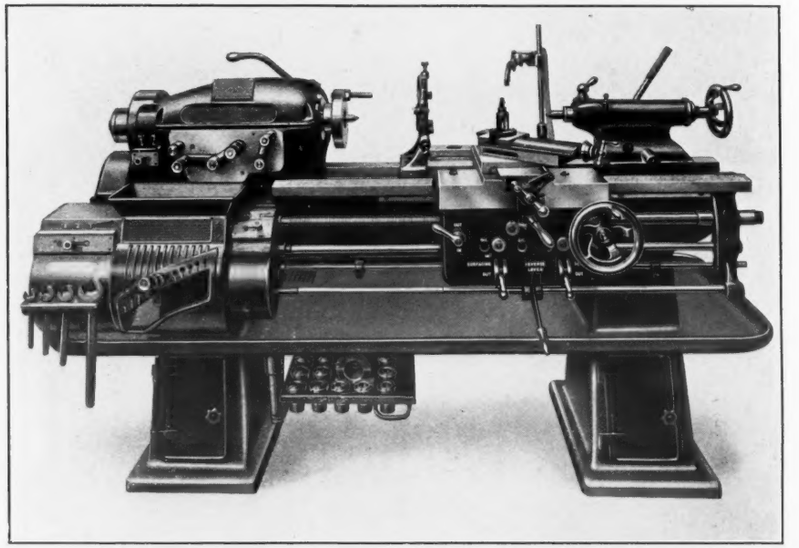


Fig. 73. 7-In. Tool Room Lathe; Messrs. Holbrook and Sons.

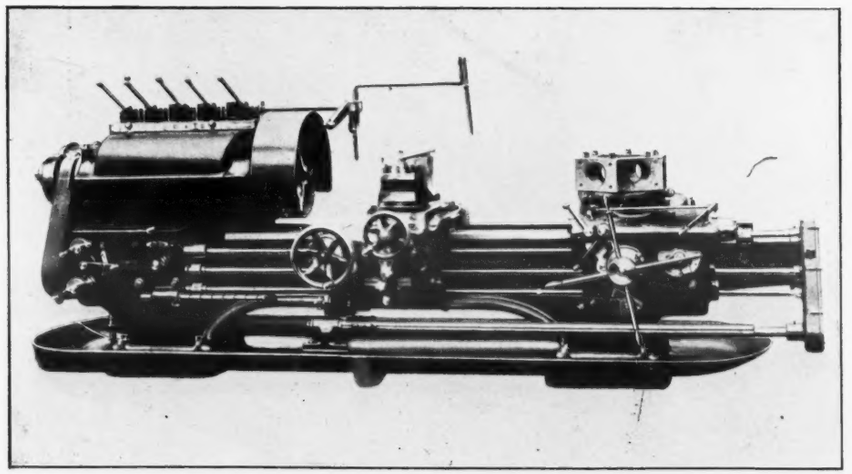


Fig. 74. 10-In. Combination Turret Lathe; Messrs. H. W. Ward and Co., Limited.

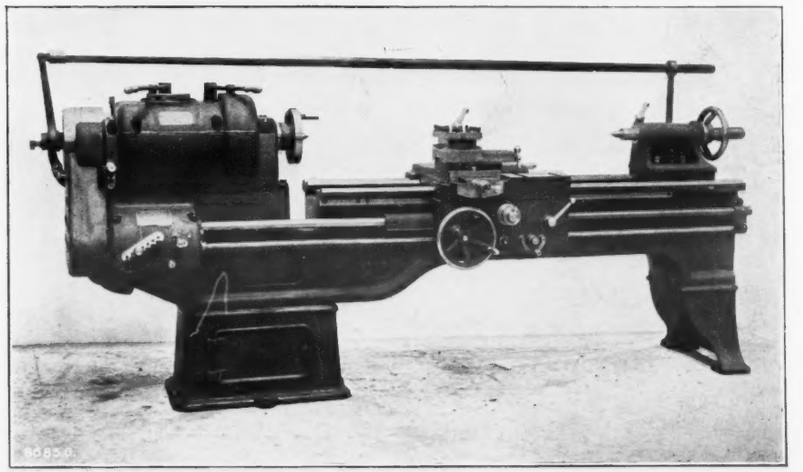


Fig. 75. 8½-In. Centre Lathe; The Selson Engineering Company, Limited.

LATHES AT THE MACHINE TOOL AND ENGINEERING EXHIBITION

(*For Description, see Page* 357.)

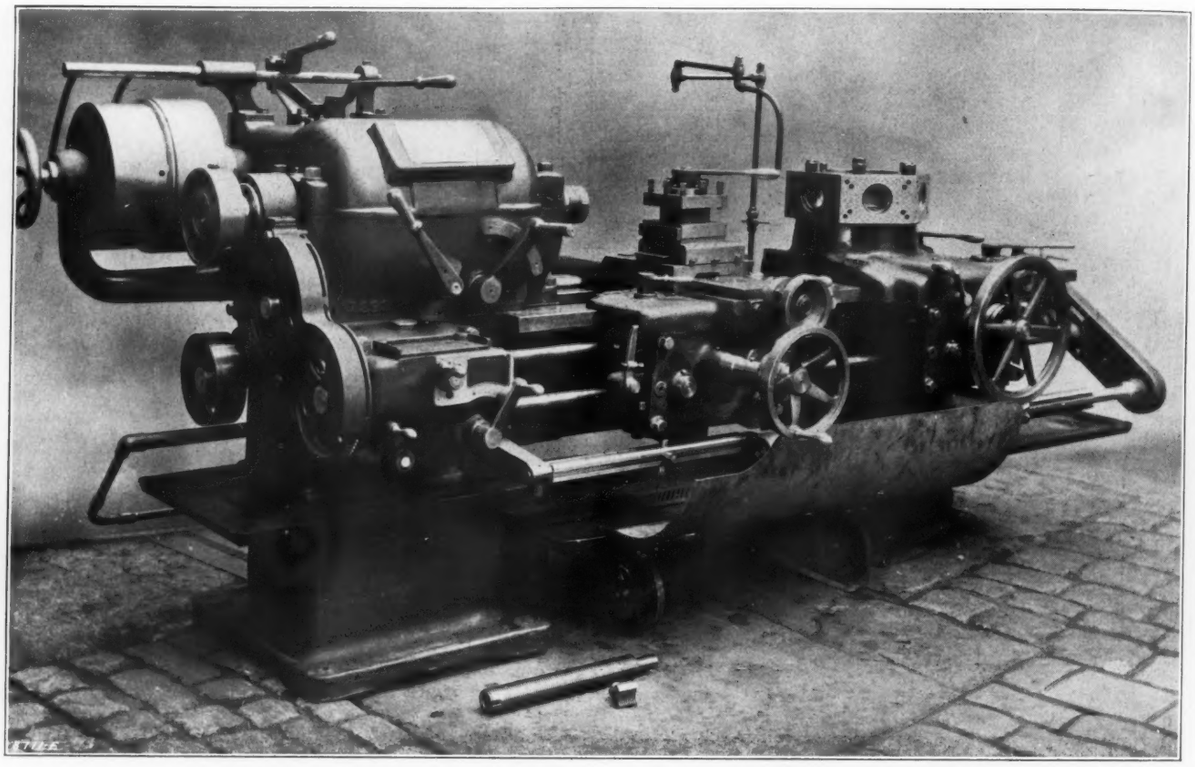


FIG. 76. 9-IN. COMBINATION TURRET LATHE; MESSRS. JOHN HOLROYD AND CO., LIMITED.

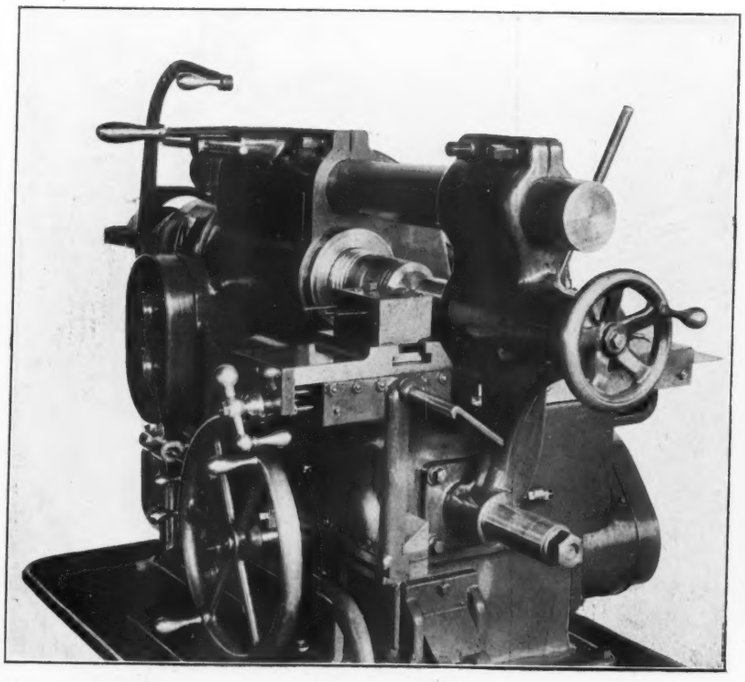


FIG 77 THE SUNDSTRAND STUB LATHE; FRONT VIEW.

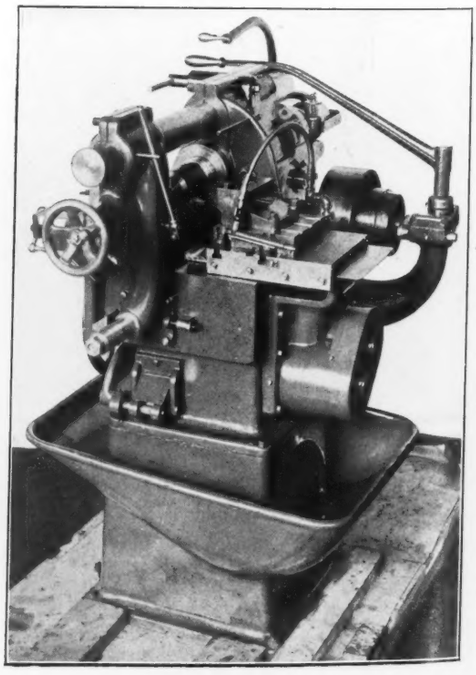


FIG. 78. THE SUNDSTRAND STUB LATHE; REAR VIEW.

(*To face page* 357.)

LATHE AND DRILLS AT THE MACHINE TOOL AND ENGINEERING EXHIBITION.

(*For Description, see Page* 358.)

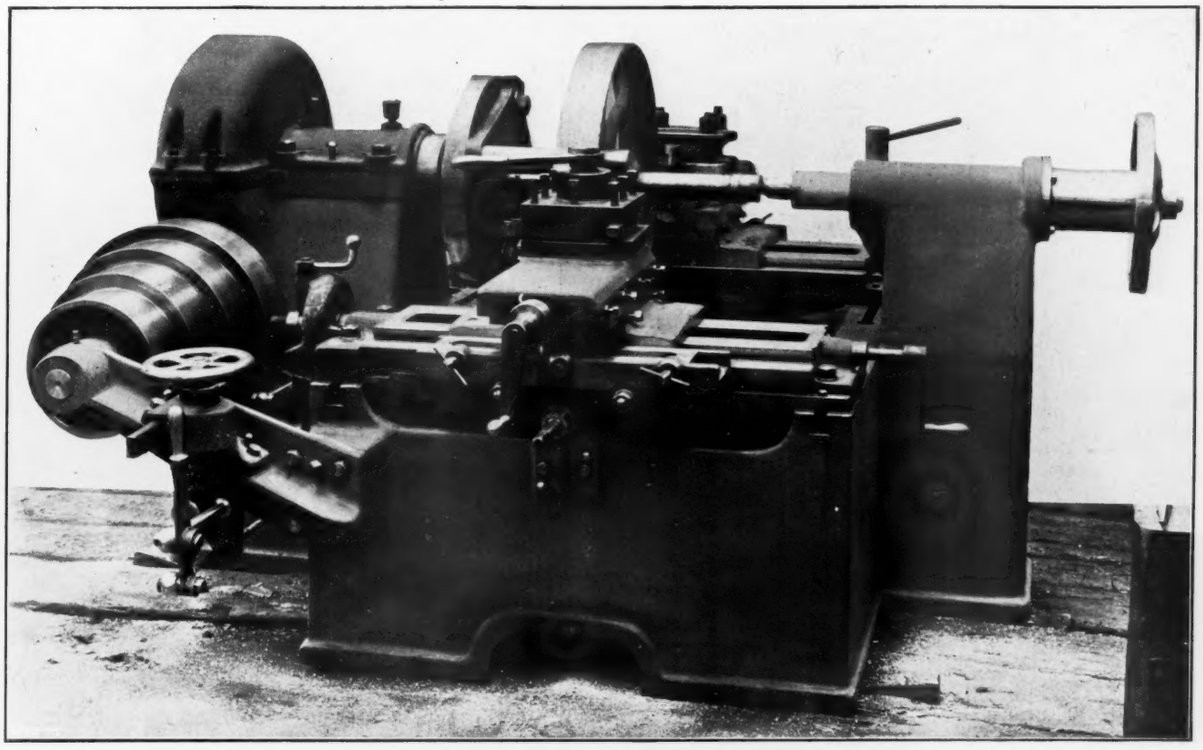


FIG 79. PULLEY LATHE; MESSRS. WARD, HAGGAS AND SMITH.

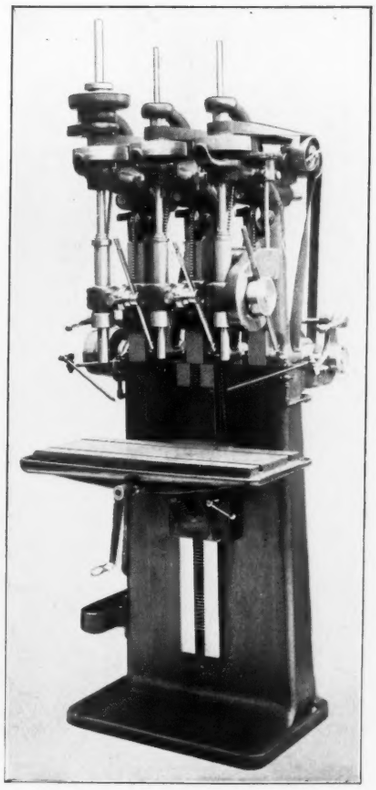


FIG. 80. MULTIPLE SPINDLE SENSITIVE DRILL: MESSRS. SMITH AND COVENTRY, LIMITED.

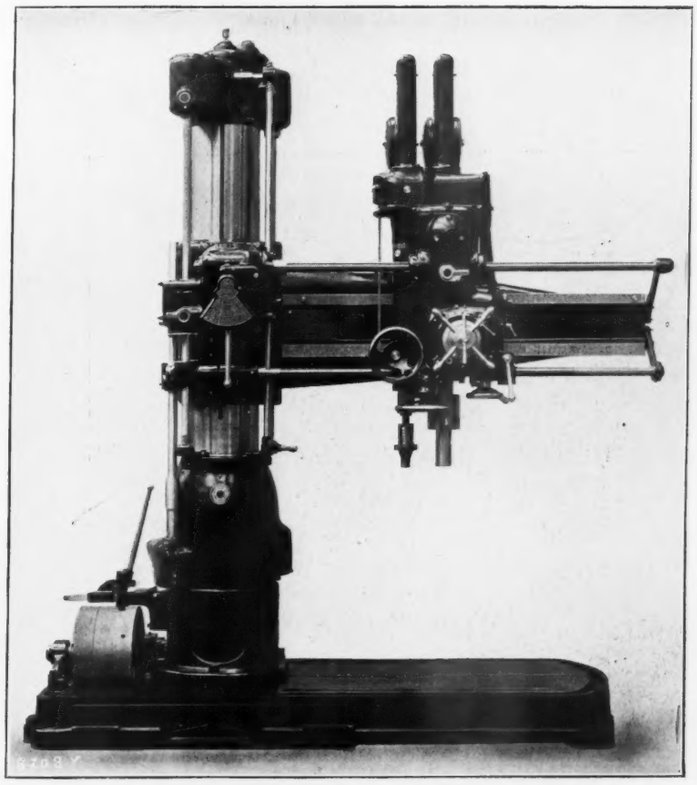


FIG. 81. 7-FT. RADIAL DRILL WITH TAPPING SPINDLE; MESSRS. WILLIAM ASQUITH (1920), LIMITED.

(*To face page* 358.)

DRILLING MACHINES AT THE MACHI TOOL

(For Descri Page 358.)

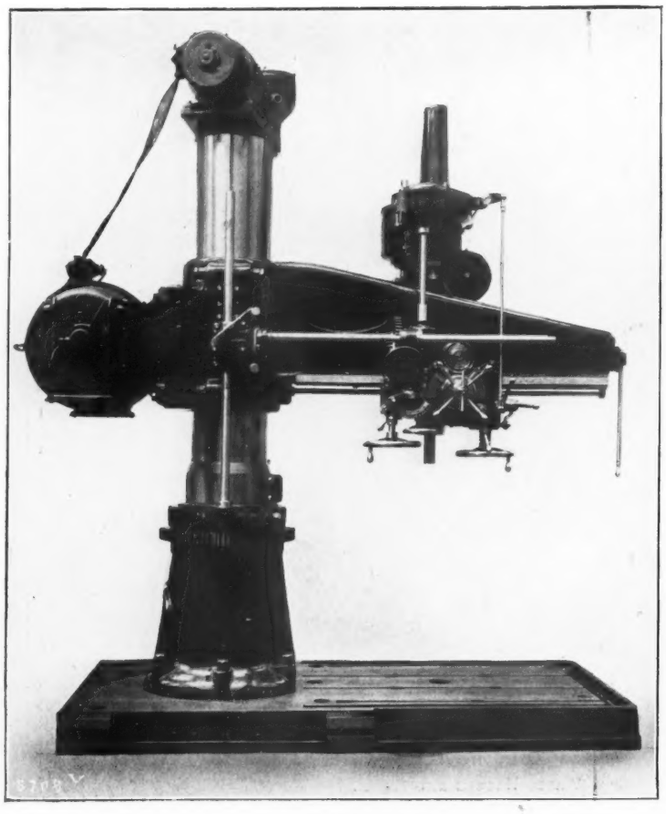


Fig. 82. 6-Ft. Central-Thrust Heavy Duty Radial Drill; Messrs. William Asquith (1920), Limited.

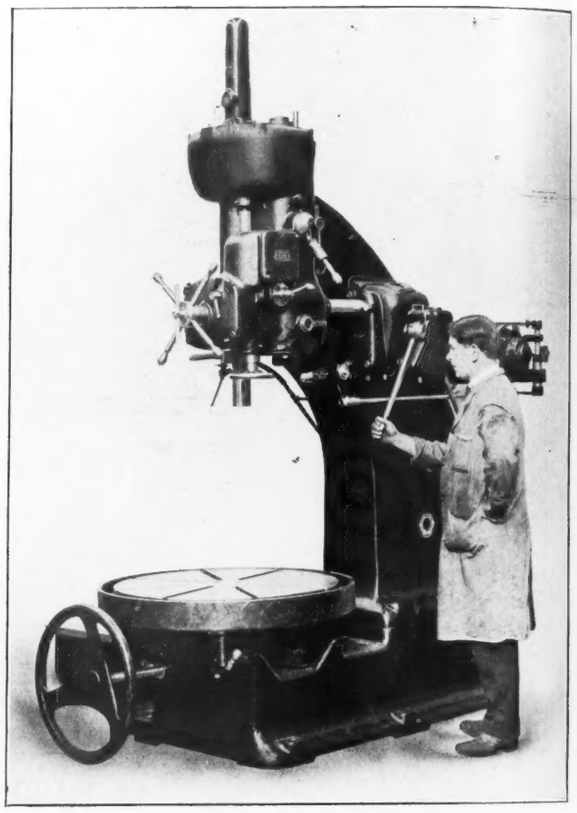


Fig. 83. Vertical Drilling Machine; Messrs. William Asquith (1920), Limited.

Fig. 84.

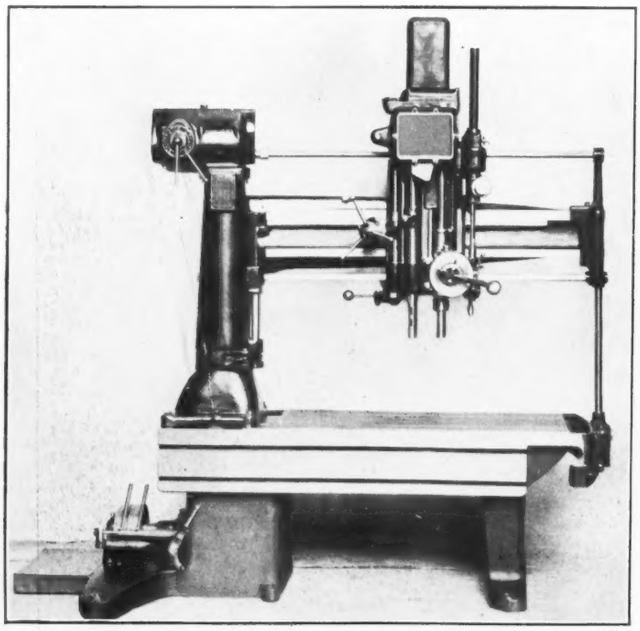


Fig. 86. Sensitive Radial Drill; Messrs. James Archdale and Co., Limited.

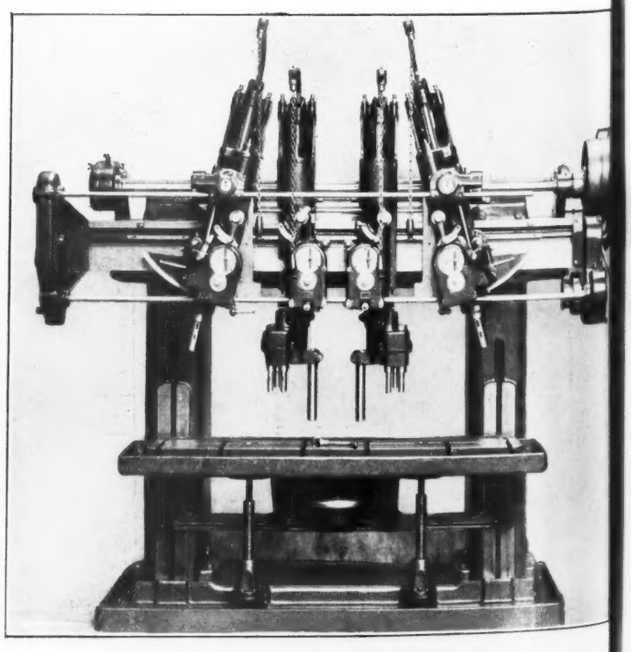


Fig. 87. Gang Drill for Motor Car Front Axles; Messrs. James Archdale and Co., Limited.

Fig. 8

CHI TOOL AND ENGINEERING EXHIBITION.

(For Descri Page 358.)

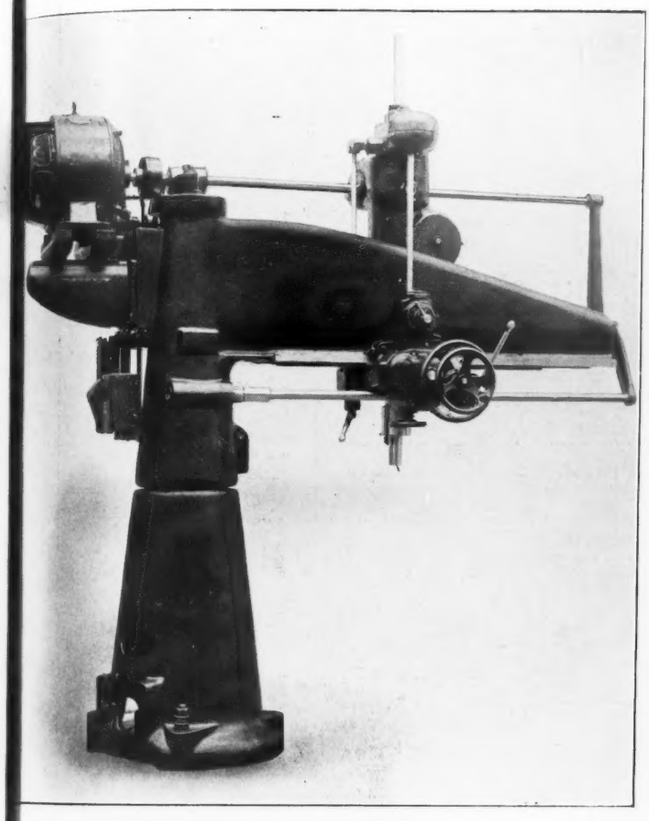


Fig. 84. Central-Thrust Girder Radial Drill; Messrs. William Asquith (1920), Limited.

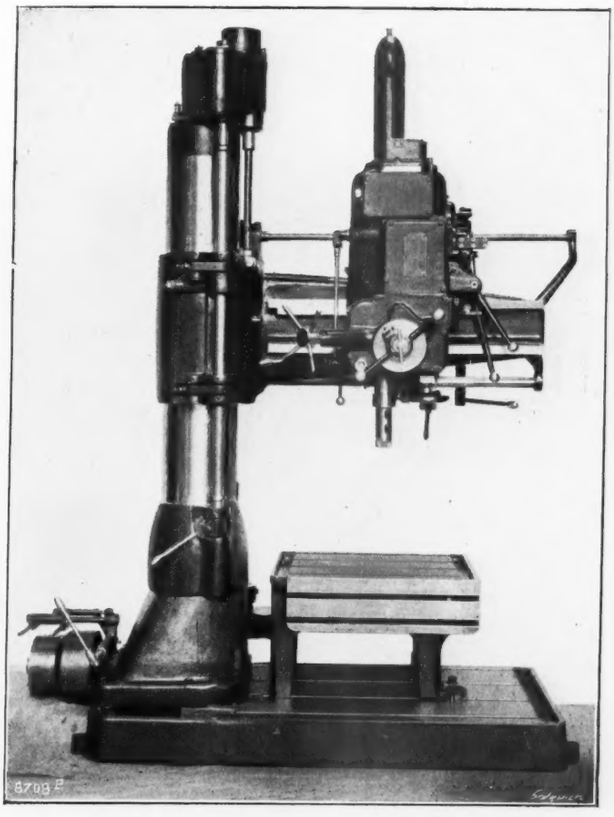


Fig. 85. 4-Ft. 6-In. Radial Drill; Messrs. James Archdale and Co., Limited.

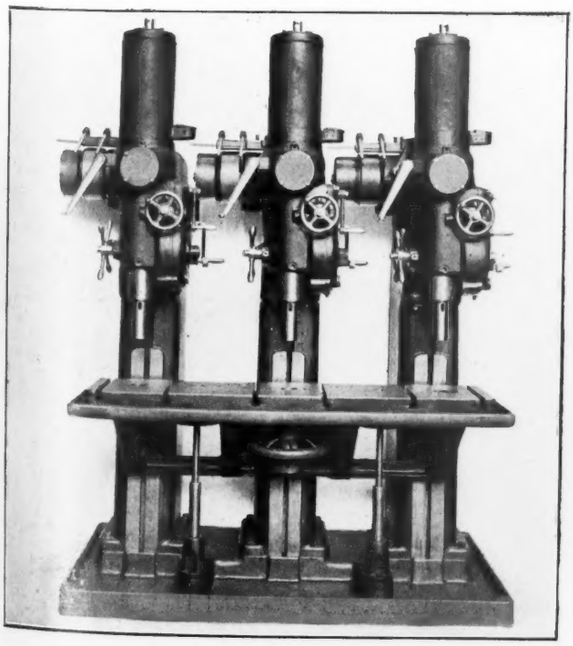


Fig. 88. Heavy Duty Multiple Vertical Drill; Messrs. James Archdale and Co., Limited.

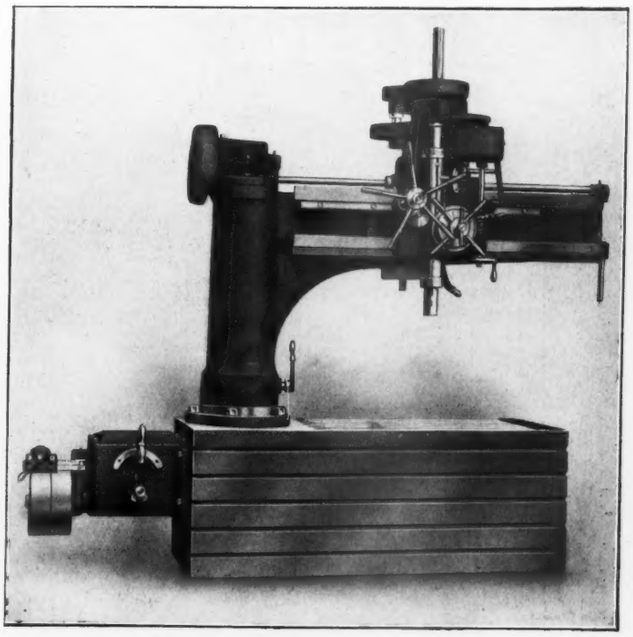


Fig. 89. 5-Ft. 3-In. Radial Drill; Messrs. Crossley and Co.

30-IN. SHAPING MACHINE AT THE MACHINE TOOL AND ENGINEERING EXHIBITION.

CONSTRUCTED BY THE SELSON ENGINEERING COMPANY, LIMITED, ENGINEERS, LONDON.

(*For Description, see Page 359.*)

Fig. 90.

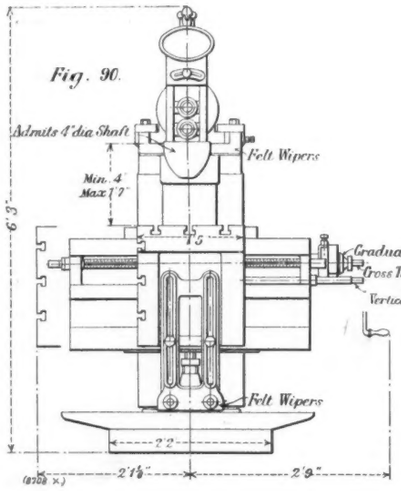
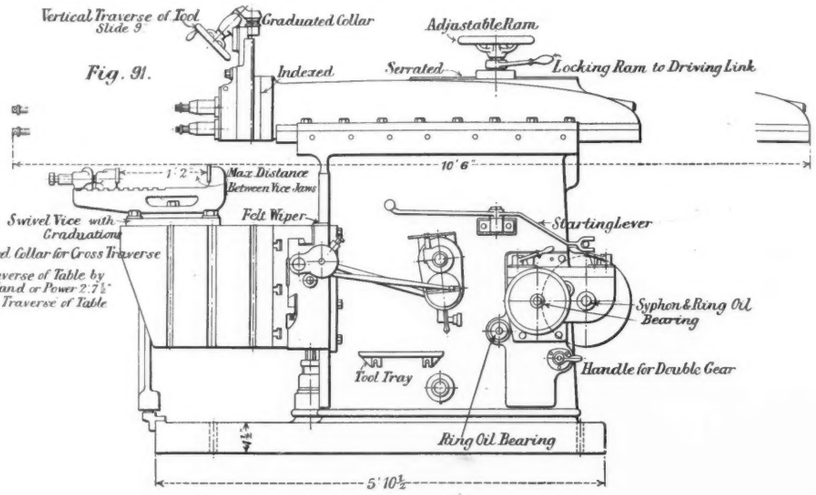


Fig. 91.



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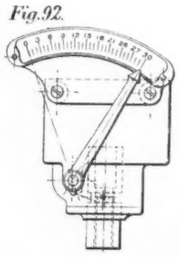

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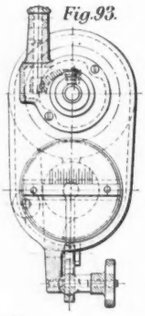


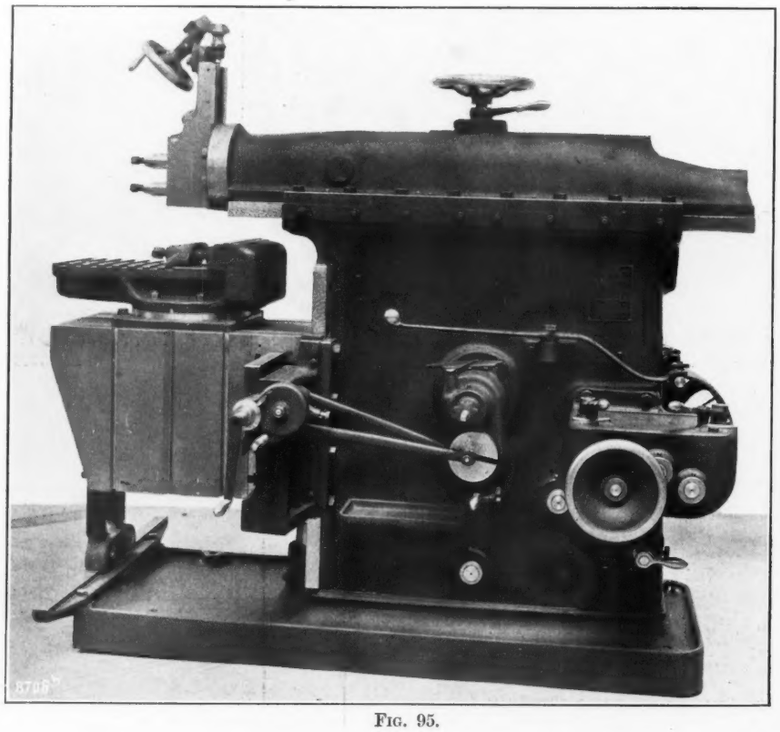


FIG. 95.

Fig. 94.

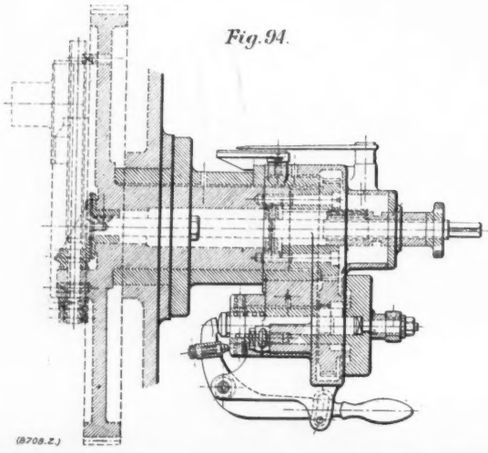


Fig. 96.

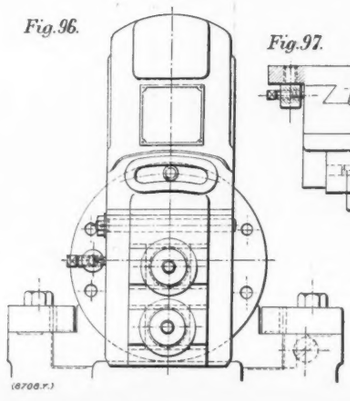


Fig. 97.

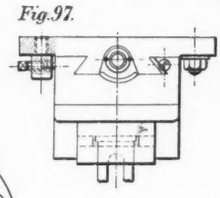
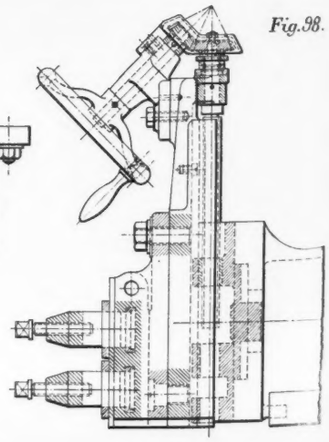


Fig. 98.



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PLANING MACHINES AT THE MACHINE TOOL AND ENGINEERING EXHIBITION.

(*For Description, see Page* 362.)

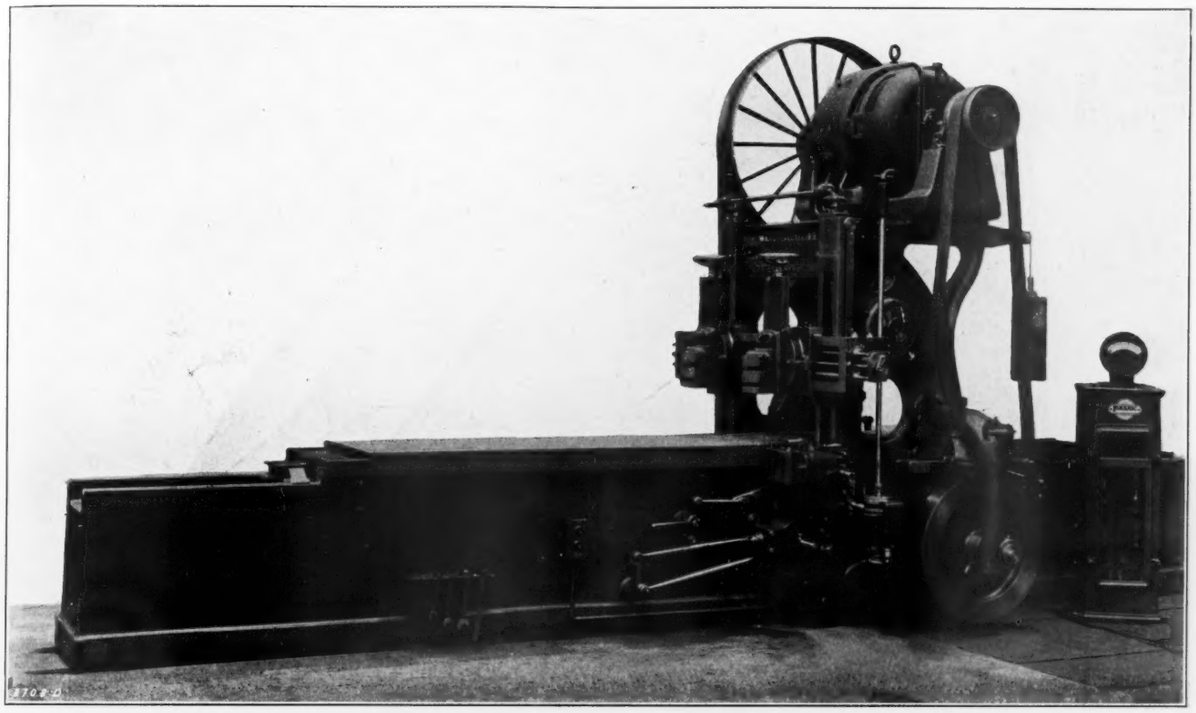

FIG. 110. BATEMAN HIGH-SPEED PLANING MACHINE; MESSRS. WARD, HAGGAS AND SMITH.

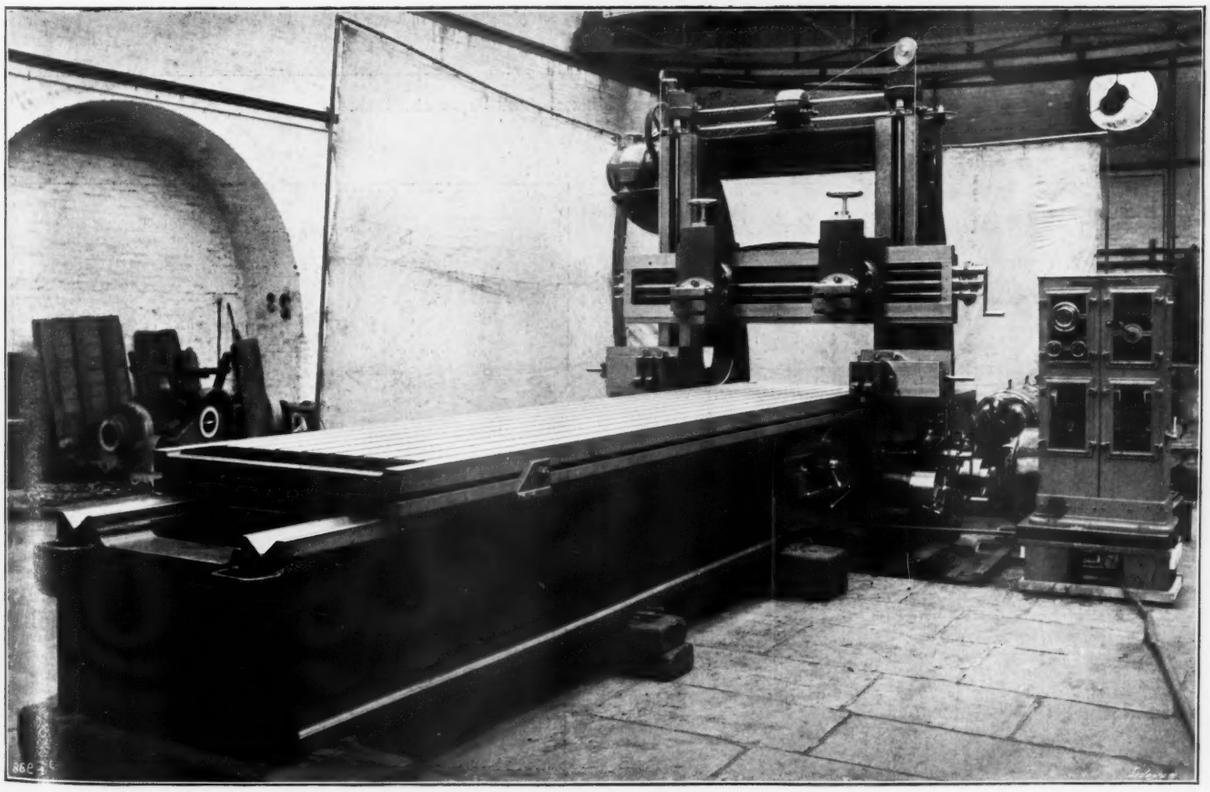

FIG. 111. 16-FT. PLANING MACHINE; THE BUTLER MACHINE TOOL COMPANY, LIMITED.

(*To face page* 362.)

PLANING AND SLOTTING MACHINES AT THE MACHINE TOOL AND ENGINEERING EXHIBITION.

(*For Descriptions, see Pages* 362 *and* 363.)

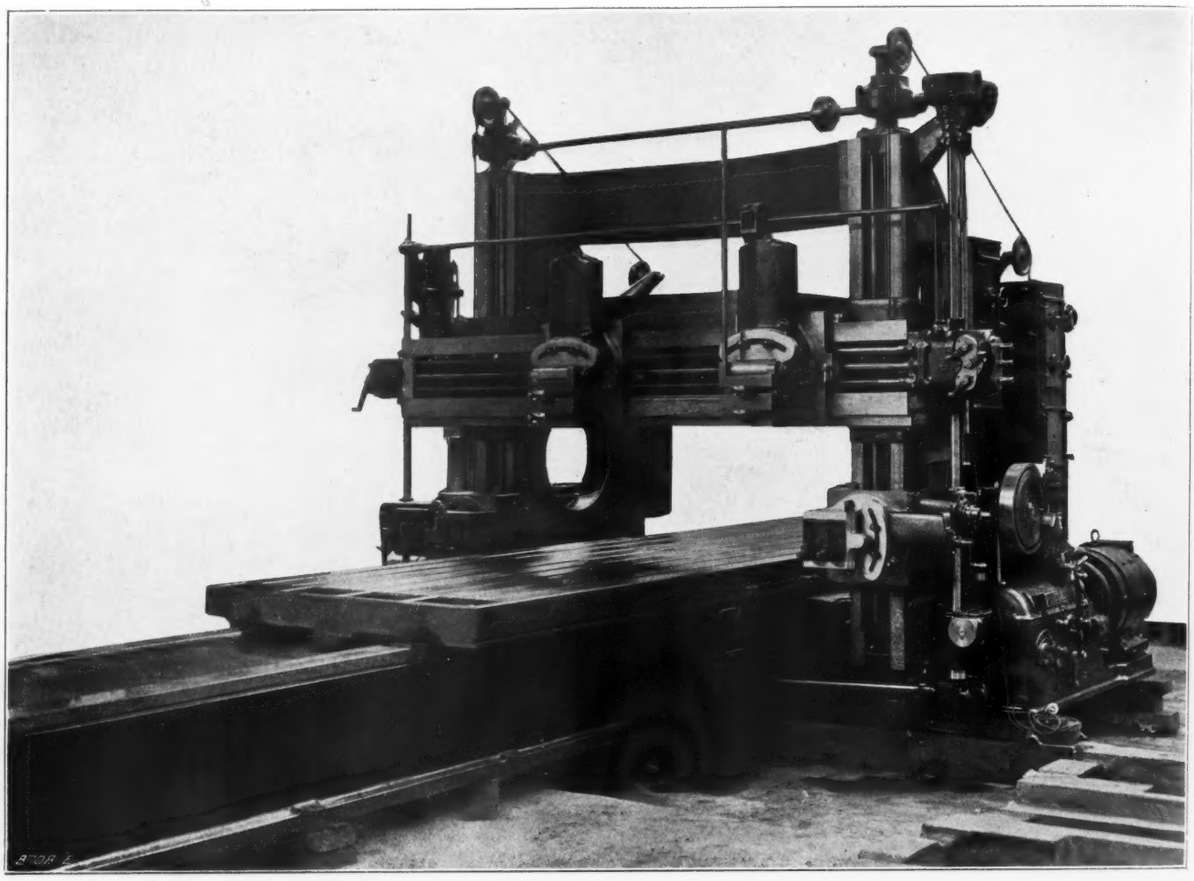

FIG. 112. 100-IN. WIDTH HILOPLANE; MESSRS. JOHN STIRK AND SONS, LIMITED.

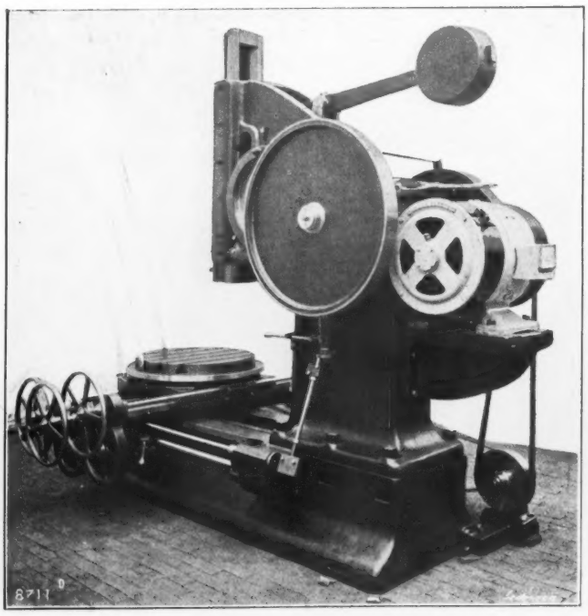

FIG. 113. 14-IN. SLOTTING MACHINE;
THE BUTLER MACHINE TOOL COMPANY, LIMITED.

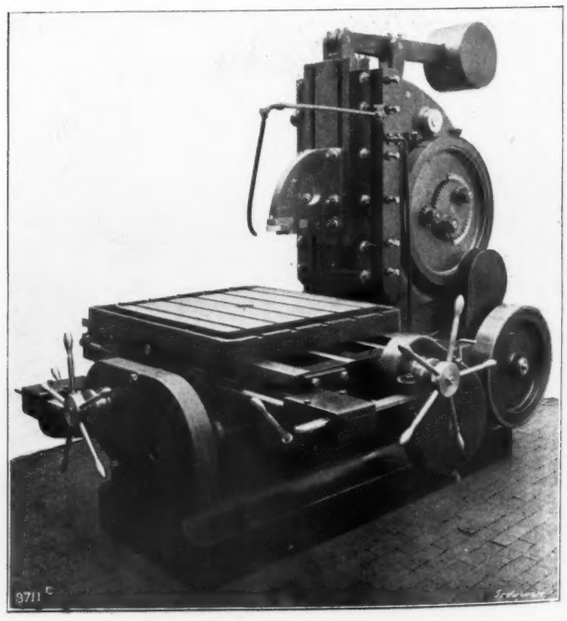

FIG. 114. 10-IN. PUNCHER SLOTTER;
THE BUTLER MACHINE TOOL COMPANY, LIMITED.

(*To face page* 363.)

ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C.2.

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One Two-Page Plate and Six One-Page Plates.—THE MACHINE TOOL AND ENGINEERING EXHIBITION.

ENGINEERING.

FRIDAY, SEPTEMBER 12, 1924.

PUBLIC SERVICE AND THE ENGINEER.

ONE of the most prolific of our present day prophets has predicted that we shall be governed to the end of time by the lawyer and the politician. Human nature being what it is, past experience renders it probable that this forecast will prove in greater accord with the actual course of events than the vast majority of the varied vaticinations which have emanated from the same source. That such a condition of affairs is not wholly satisfactory has long been recognised, and it appears that in America in particular, a strong feeling has been manifest for some years past that engineers should play a more active part in public affairs than has been customary in the past. As to the abstract desirability of such a change there can be little difference of opinion. At least twenty good reasons could be advanced in favour of such a policy, and perhaps not more than one against it. In the well-known fable, however, the cat's one trick of running up a tree to escape from the dogs, proved to outweigh in effectiveness, the whole twenty of the boastful, but ingenious fox, and there is a danger that the one disability of the engineer for a public life, may well prove an insuperable bar to the profession as a body playing any prominent part in municipal and national affairs. At least this seems likely to hold good in normal conditions, though when emergencies arise—when it is a matter of getting good work done rather than of scoring dialectic triumphs—the engineer may again be called upon to fill ministerial and administrative positions.

The particular disability for public affairs which we have in mind lies in the fact that the whole of an engineer's training tends to unfit him for a political career. Like Kipling's Mariner, the engineer "serves no easy cheated altars" but "a jealous and oppressive god," and his work is judged by far more rigorous standards than are applied to the politician. The failure of the Tay Bridge ruined the professional status of Sir Thomas Bouch and probably contributed to his early death, but the fact that the late Lord Morley qualified as the "false prophet of the Soudan" seemed to do little or no injury to such reputation for foresight and sagacity as he happened to possess.

As Mr. Elihu Thomson pointed out at the Kelvin commemoration, the engineer stands alone amongst professional men in that he has to guarantee results at his own personal risk. The politicians, on the other hand, who imposed on London the tramway services which in the coming year will require a contribution of some 360,000*l.* from the rates, made very confident claims as to highly-profitable returns, but their guarantee was a mere matter of phraseology. At worst, the politician who makes a mistake may lose his seat in consequence, but he runs no real risk of any serious personal inconvenience, and it is probably this consideration which makes work on the municipalities and in parliament so attractive to the many who love to exercise power without involving themselves in any serious personal responsibility.

No engineer, moreover, dare trifle with natural laws in the same way that the government of the day did with its "principles" when, for example, the Trades Disputes Bill was under discussion. In that case official orators repeatedly pointed out that certain provisions of the bill violated considerations of justice, but when the pinch came these protests were forgotten, and like one of the heroines in Don Juan, the government, swearing they "would never consent, consented." The whole of an engineers' training tends to deprive him of any similar pliability. Natural laws being based on observation and experience, and not upon *a priori* plausibilities, cannot be violated with any corresponding impunity. Evidence, not strength of volition, is the basis of the engineer's beliefs, which thus constitute a policy rather than a creed.

It would undoubtedly be greatly to the public benefit if more of this spirit could be imported into the discussion of public questions, and that such matters as the nationalisation of railways or of mines, or the respective merits of free trade and protection, should be dealt with from the point of view of recorded experience, rather than as logical deductions from hypothetical first principles. It would then be recognised that radical changes should only be introduced tentatively and experimentally, on a small scale and not on a large one, so that mistakes might be readily rectified or a policy reversed if experience thus gained should indicate that hopeful anticipations were likely to be falsified.

The view appears to be widely held by town councillors, aldermen and ministers of State that the technical expert is unfitted for an administrative position. As Mr. Sidney Webb argued at the recent congress of science and labour, they hold that the experts should act solely as consultants, leaving the actual work of administration to laymen having what Mr. Webb termed the characteristics suited to government. This arrangement has been largely followed in our Government services, where, as Lord Sydenham has observed, it is too frequently the case that the man who knows all about a certain matter has to report to one who knows less about it, and the ultimate decision is frequently made by the man who knows nothing. Another drawback attaching to the system is that unpalatable reports may be suppressed, as for example by that Lancashire town which, on taking over the gas works, instructed its gas examiner that he must no longer publish reports indicating bad gas.

The commissioner system in America and Canada was admittedly very successful in conducting all public services, yet in town after town the system was abandoned after trial and the previous extravagant and wasteful methods restored. Possibly this was due to the circumstance that the commissioners were more or less autocrats, and though highly successful as administrators, had

little personal intercourse with the "common people," and conducted no propaganda to imbue them with the view that the methods of science are as applicable to social and economic questions as to purely technical matters. During the war again we had quite a number of ministerial posts successfully filled by very able men who were essentially non-politicians. With the restoration of more normal conditions, however, these men, in spite of their past success, proved unpopular. They lacked presumably what Mr. Webb called "the characteristics suited to government," although their administrative powers had been proved in railway management, or the building up and conduct of other great industrial undertakings. A Carnegie, following the dictates of his individual judgment, developed the greatest steel-making business in the world, but he might quite probably have done nothing of note had he been compelled to justify every venture to doubting colleagues or to an opposition who took the view that the main duty of an opposition was to oppose. Genius is, in fact, essentially individualistic, and for full development must have more or less autocratic powers. It is here that all systems of co-operative or public management break down. The co-operative societies have not founded a single new industry nor is any important improvement in transport attributable to State railways. Like government departments these have been managed just by ordinary clever men. The man that possesses the "little more," of which Browning emphasised the importance, is ever unhappy as a departmental officer.

A parallel to the history of the town commissioners is afforded by the history of the Australian State railways. At the outset the attempt was made to take the railways "out of politics" by entrusting the administration of them to expert commissioners, but in the course of years many of the powers originally held by these have been transferred to the politicians, and it appears that there are evidences of a similar tendency in connection with the South African railways. In view of these experiences, it will be of interest to learn for how many more years the Hydro-electric Commissioners of Ontario will be allowed to retain their present powers.

The commission system seems, indeed, to be doomed, and the engineer who wishes to serve his town or state must, apparently, do so on the same terms as the non-expert, and seek election in the ordinary way. From an address delivered a few months ago to the Engineers' Society of Western Pennsylvania by Mr. Morris Knowles, we learn that not a few trained engineers in America have "gone into politics" there, and it will be interesting to note whether their early training or their new environment will ultimately secure the mastery. Mankind has no doubt an extraordinary capacity for thinking in watertight compartments, and hence the two may in many cases never come really into violent collision, but still the main hope for the future does lie in a greater recognition of the methods of science as compared with those of the lawyer and schoolman who have controlled public affairs in the past. The influx into public positions of men with a technical training ought to tend to good, though it is probably true that no man with any marked capacity for making important advances in either pure or applied science would take by choice any alien career. Such an exceptional genius would fail to be attracted even by such a prize as the presidency of the United States or the premiership of Great Britain. His ambitions would lie rather in the craving to add something of definite importance to the sum total of human knowledge and achievement, than to play the most prominent of roles in party manipulations. It is probable, moreover, that, as already indicated, a man of real creative genius would prove out of place in public affairs as now conducted. Even as matters stood under Napoleon, Laplace proved a failure as departmental head. He brought in matters of administration "the spirit of the infinitesimals." Newton was a greater success as master of the mint, but he had there much scope for the exercise of his scientific powers, as many technical operations were being badly and inefficiently conducted. Whether he would have given equally steady attention to his duties had they been of the ordinary routine type is a matter of surmise, but even as matters stood it was asserted by some that science lost more by this appointment than the mint gained. In fact it is quite probable that he would never have accepted the post, even as matters stood, had he been, like Charles Darwin, possessed with independent means.

NON-FERROUS METALLURGY IN AMERICA.

THE third autumn lecture to the Institute of Metals was delivered on Monday evening last, in the building of Institution of Mechanical Engineers by Mr. W. M. Corse, who said that he proposed to describe some of the more important developments which had been recently made in America in the utilisation of non-ferrous metals, devoting special attention to nickel and its alloys and to the aluminium bronzes, and he would also refer to the advances made in the use of metal moulds for castings. The lecturer described briefly the history of nickel alloys some of which were used for coinage as far back as 235 B.C. There was little further development, however, until quite recently. Indeed, nickel owed its name to the fact that its ores were mistaken by German miners for copper ores, which as they could not be reduced to copper were dubbed Old Nick's copper, and cast aside in contempt. The metal was, in fact, not isolated till 1751, but it only entered extensively into commercial metallurgy after the publication, in 1889, of Mr. James Riley's paper on nickel steel. The original of this later research was peculiar. A certain Mr. Gamgee in 1876 conceived the plan of constructing a refrigerated ship, which was intended to visit the yellow fever area and to receive patients on board, the idea being to freeze out the germs. To this end he required an alloy which would "hold" ammonia, and decided to try an iron-nickel alloy. He brought the matter before Mr. Ritchie who was the principal owner of copper-nickel mines in Canada, and the latter succeeded in interesting British steel makers, and thus led to the production of Riley's paper. About the same time, it was discovered that the addition of nickel to armour plate made a marked improvement. In 1894 Edison used the metal for his alkaline storage cell. The alloy of copper and nickel, known as monel metal, was introduced in 1905, and was now being made on a very large scale at Huntingdon, in Virginia. This alloy occurred naturally in the reduction of certain copper-nickel ores, but a similar material was being made synthetically from copper and nickel by Messrs. Henry Wiggin, of Birmingham.

The peculiar chemical and physical properties of nickel presented a baffling problem to the metallurgist, and the earlier attempts at effecting its separation from copper involved many disappointments, but the very properties that occasioned these difficulties were those on which the usefulness of the metal depended. Nickel ores were very widely distributed but, practically speaking, the whole output was now derived from three sources: Canada, New Caledonia and Norway. Canada was responsible for 90 per cent. of the total production. The mine was discovered in 1883, during the construction of the Canadian Pacific Railway. The ore as mined seldom contained more than 5 per cent. of the metal, so that much concentration was necessary. In addition to nickel these ores contained copper, and small percentages of the metals of the platinum group and of gold and silver. The New Caledonian ores were quite different. They were free from sulphur and contained no copper. The Norwegian ores were similar to the Canadian, but of lower grade. During the war, however, they were worked profitably to meet the requirements of Germany. Two main methods were used in reducing the Canadian ores, that of the International Nickel Company of Canada and that of the Mond Nickel Company. The process used by the latter was of particular interest, since use was made of the fact discovered by the late Dr. Mond in 1889 that nickel formed a volatile carbonyl when carbon monoxide gas was passed over it at temperatures between 30 deg. C. and 70 deg. C. and that this carbonyl was decomposed at a higher temperature, depositing metallic nickel. The nickel thus produced assayed 99·8 per cent. of nickel and was free from cobalt.

Whatever process was used the reduction of nickel involved many steps, and was much more complicated than the reduction of copper.

The pure metal took a more brilliant polish than platinum and was not attacked by sea water. It would, moreover, resist for a long time attack by organic acids. Its melting point was 1452 deg. C., and commercial qualities had a specific gravity ranging from 8·7 to 8·9. The Brinell hardness of the cast metal was about the same as that of mild steel. As cast it had a strength of 25 tons per square inch, but rolled, this figure rose to 33 tons, whilst by cold rolling a tensile strength of 44 tons per square inch could be obtained, and in the form of wire the tensile strength might be over 70 tons. The yield point of the cast metal was 9 tons, and of the hot rolled metal 11 tons per square inch. The metal lost its magnetic properties at temperatures above 350 deg. C.

The world production was now about 35,000 tons per annum. Of this only some 5 per cent. was used for electroplating. In pre-war conditions the nickel steels were used mainly for armour and guns, absorbing thus 60 per cent. of the output. Other alloys took 25 per cent., whilst malleable nickel formed about 5 per cent. and miscellaneous uses accounted for the remainder. The disarmament agreement had at first reduced largely the demand for nickel steels, but other uses had been found for this product, as for example in bridge work and for automobiles, so that the tonnage was now equal to the pre-war figure. Mention might be made of two peculiar nickel steel alloys, viz., that containing 34 per cent. to 36 per cent. of the metal which had nearly a zero coefficient of expansion with temperature, and that with 46 per cent. of nickel which had the same coefficient expansion as glass, and was therefore largely used for "leading in" wires. A peculiar property of nickel was its power of decolourising the metals with which it was alloyed. Thus, 1 part of nickel decoloured 3 parts of copper, the alloy being known as nickel silver. Nickel had 10 times as great a resistance to abrasion as silver, and this had led to its use for coinage in pre-war times. These coins were melted up during the war to make the nickel steels, but the demand for nickel coinage had increased so much of late that 1,800 tons were thus used in 1923.

The monel metal alloy which contained 67 per cent. of nickel and 28 per cent. of copper, the remainder being iron manganese and carbon, resembled nickel in appearance. It resisted corrosion and retained its strength and hardness at high temperatures. It combined the physical properties of steel with most of the chemical properties of nickel. The tensile strength ranged from 33 to 45 tons per square inch, and the elastic limit from 18 tons to 33 tons per square inch. The elongation on 2 in. ranged from 30 per cent. to 50 per cent. and the Brinell hardness number from 160 to 190. It was found specially serviceable for withstanding severe shocks, and in all cases where toughness was required to be combined with strength. It lost its magnetic properties at a temperature a little above 100 deg. C. This alloy was a very interesting metal and met a long felt want, but it had, of course, its limitations, and would dissolve in strong acids or when exposed to certain molten metals.

Nickel formed solid solutions with 7 of the 22 commoner metals, and dissolved important quantities of eight others. With 12 of the commoner metals the alloys were of commercial value. Over 420 chemical compounds of nickel had been enumerated, and its use as a catalyst in the hydrogenation of oils had proved very valuable.

Aluminium bronze, the speaker continued, was another non-ferrous product which was being very largely used in the United States. Much of the development was based on the work of the Alloys Research Committee of the Institution of Mechanical Engineers published in 1907, which had been supplemented by American researches. Its outstanding property was its resistance to corrosion, and to alternating stresses, whilst in hardness and strength

it was comparable with steel, and like steel, special properties could be imparted by heat treatment.

The 10 per cent. alloy as cast, had a tensile strength of 74,500 lb. per square inch, and an elastic limit of 19,800, whilst the elongation was 19·5 per cent., and a reduction of area of 23·7 per cent. The addition to this of 1 per cent. lead gave a tensile strength of 72,600 lb., a yield point of 25,100, whilst the elongation and reduction of area were increased to 25 per cent. and 26·9 per cent. respectively. The addition of iron to the alloy raised the strength and the elastic limit. Alloys of large cross section were self-annealing, but with the addition of iron they were no longer self-annealing. For worm gear wheels it had been found advisable to keep the aluminium between 10 per cent. and 11 per cent., brittleness being the result of a larger proportion.

The alloy was free from hot shortness, and could be rolled and forged hot, and could be cast in metal moulds. This latter property had led to a very extensive use of the alloy for automobile parts. Bevel gears thus produced were used as cast, and such castings were extensively employed by the Ford Company who, since 1916, had used eleven million pounds of such castings for the worm wheels of their 1-ton truck and two million pounds for other parts. The results had been most satisfactory. For six years there had been no failures at all and since 1922 the total failures recorded had not exceeded 2 per cent.

More recently, the worm wheels had been made with 2 per cent. of lead added to the aluminium-bronze. This alloy had a tensile strength of 82,200 lb. per square inch, a yield point of 30,700 lb. per square inch, an elongation of 15·3 per cent., and a reduction of area equal to 16·0 per cent. A service test was made in which the "one ton" design was fitted to a truck having a "5 ton engine" and a 4-ton body. This was run for 1,000 miles in a hilly district. Subsequent examination showed no signs of wear or abrasion.

The alloy was not so readily machined as some of its rivals, but with proper cutting speeds and tool angles there was no real difficulty.

Metal moulds were being successfully used also for other metals besides the aluminium-bronzes, and in particular for cast-iron. The moulds were themselves of cast-iron, and in the earlier experiments had been made with thick walls, which resulted in cracks and rapid wear. They were now made lighter, and steps taken to ensure that their temperature never rose above 850 deg. F., so as to avoid "growth." The Holley Carburetor Company used cast iron moulds $\frac{1}{2}$-in. thick to produce intricate iron castings, ranging from $\frac{1}{8}$ in. to $\frac{1}{2}$ in. in thickness, and these castings were free from pores and quite soft throughout. The average foundry loss in this particular product was 7 per cent. to 8 per cent., as against 20 per cent. when made in sand. The work was done by machines tended with unskilled labour, and each machine produced 2,000 castings in five hours, which was eight times as much as with sand moulding, and the product was of better quality; in fact, castings were thus produced which could not be made at all in sand moulds.

The moulds had radiating fins, and the rate of cooling was controlled by an air current. They were heated to a definite temperature before use, and maintained at this in service. The moulds lasted generally for 8,000 to 10,000 casts, and a life of 25,000 casts had been recorded. They were coated with a wash of water, fireclay and water glass, to a depth of $\frac{1}{64}$ in., and this clay lining lasted a month. The clay was coated with lamp black, and this lamp black facing was renewed after every cast. The shrinkage of the metal was only as half as much as with sand moulding, and the dimensions of the castings "held" within $\frac{5}{1000}$ in.

More development work was needed, but for certain castings the process was now an assured commercial success.

At the conclusion of his lecture Mr. Corse exhibited cinematograph films taken at the Huntingdon works. These showed in progress the various operations of furnace charging, ingot casting and forging, and also the machinery of the ingots to get rid of any contaminations which the skin may have absorbed from the mould.

ELECTRICITY SUPPLY IN GREAT BRITAIN.

THE fourth report of the Electricity Commission, just issued* is accompanied by a separate pamphlet, giving analyses and summaries of the returns of fuel consumption made by the various authorised undertakers for the year ending March 31 last. The total units generated at steam stations amounted to 6,342,107,841, and the fuel used to 7,561,991 tons, so that the average consumption was 2·67 lb. of coal per kw. hour. A comparison with the corresponding figures for the previous year shows that production was increased by 16·4 per cent., and the fuel consumption by 11·3 per cent., the coal per kw.-hour being 2·78 lb. for the year ending March, 1923. It is evident that the new large and economical units which have been recently installed are effecting an appreciable economy in coal, but the Commissioners report that much still remains to be done. A reduction of the average coal consumption per unit generated to 2 lb. would result they say, in a saving of 20 per cent. of fuel, whereas at a number of the large stations, figures well below the 2-lb. limit have been recorded. The pride of place in this matter is now taken by the new Barton Station of the Manchester Corporation, where the average fuel consumption was 1·48 lb. per kw.-hour. This particular return refers, however, to less than half a year's working, as the station was not started up till October, 1923. This station is new throughout, and not saddled with either obsolescent machines or with the drawbacks to economical working, which often are encountered when a station grows from a small capacity to a large one. In such case, it is often impossible to arrange the additional plant as conveniently and economically as when constructing an entirely new station. The North Tees Station, of the Newcastle Electricity Supply Company, stands second with an average fuel consumption of 1·67 lb. per kw.-hour, a result which is possibly somewhat disappointing, but this station represented, it will be remembered, a bold pioneering advance by which all stations subsequently designed have benefitted. The third place is taken by Carville, at which the consumption averaged 1·81 lb. per kw.-hour. This is a really remarkable performance for a station which has been pre-eminently the pioneering power station in this country; and which has time after time established new records in the economical generation of electricity.

In thermal efficiency, Barton again stands first with a record of 20·33 per cent. The North Tees station comes next with a figure of 17·60, and Glasgow third with a thermal efficiency of 17·47 per cent. After this, there is a rapid tailing off, and the best of the steam stations with an output of between 100,000 units to 250,000 units per year showed a thermal efficiency of but 2·96 per cent. No figure is given for the worst of these, but the Queenborough Pier station of the Southern Railway consumed 11 lb. of coal per kw.-hour., and this was best fuel consumption in its class.

Three stations produced over 200 million units per year, and eight between 100 million and 200 million units. The most numerous stations were those producing between 25 million and 50 million units per year, but stations with an output of between one and two million units were nearly as numerous.

The report also gives figures for stations operated with gas and oil engines, and here it is noteworthy that the large steam stations are much more economical of fuel than the stations operated with producer gas. In practice, therefore, it would seem that the steam turbine has definitely beaten the gas engine; since the best thermal efficiency recorded for the latter was but 14·08 per cent. Of course, the output of these stations was small, but it is generally admitted that a gas engine of some 60-h.p. is about as economical as the largest made, whereas the steam turbine is essentially a large unit machine, so that it is not unfair to make a direct comparison between the best of the gas stations and the best of the steam stations.

The oil-engine stations show, on the other hand, a materially higher efficiency than the best of the steam stations. The highest thermal efficiency at an oil-engine station recorded in the report is 29·10, which is nearly 50 per cent. better than the Barton record, but it is, of course, probable that there is a greater possibility of improvement in the steam figures than in the oil-engine figures. Water-power stations have in this country an almost insignificant output, being responsible for but 0·6 per cent. of the total units generated during the year. The largest water-power station now in operation is that of the North Wales Power Company at Cwm Dyli, where the installed capacity is 5,500 kw. Powers have now been obtained for some larger plants in Scotland. The Lochaber scheme provides for a 70,000 h.p. station at Fort William, and the Grampian scheme provides for the generation of 56,000 h.p. Unfortunately, the ill-considered action of the House of Lords checked the development of Scottish water power by unreasonably rejecting one of the most important schemes when first brought forward, a procedure by which extravagantly-paid parliamentary counsel were the sole beneficiares.

The report states that, so far as can be ascertained, about half as much electricity is supplied from private plants as from all public utility stations, so that the total consumption per head of the population of the country is about 200 units per annum.

As is well known, the political and economic views of Mr. Chamberlain forced electrical development on this country on to wrong lines, with the result that we were saddled with a multitude of small stations, at which efficient generation was impossible, whilst in other cases comparatively large stations were erected in regions without an adequate supply of condensing water. Even now Salford and Liverpool have sought, and succeeded in obtaining, a reluctant consent to an enlargement of their existing badly-sited power stations.

Much of the work of the Commissioners is devoted to attempts to repair these evils and to persuade the owners of small and inefficient stations to abandon attempts at further development, and to take supplies from whoever can furnish the current most cheaply. In this matter, of course, future conditions as well as those temporarily existing have to be considered. The negotiations have not been free from difficulty, which in certain cases have been aggravated by purely political considerations. Bulk supplies are, however, proving increasingly acceptable and are taken now by 207 authorised distributors. Progress is slow, but is undoubtedly being made. Since 1920 the Commissioners have sanctioned the installation of 78 units of over 10,000 kw. rated capacity and 8 units of over 20,000 kw. capacity.

The Commissioners have also revised during the year the pre-existing regulations for overhead mains; and have mitigated certain restrictions on their use. One of the lines sanctioned on the North East Coast system is to be operated at 66,000 volts; a 49,500-volt line has also been authorised, and sixteen 33,000-volt lines.

Some difficult questions have arisen in connection with railway supplies. Powers have been sought to supply the whole of the Southern Railways lying east of Southampton and Winchester. The bodies affected or concerned in this matter include 200 local authorities, of which 40 are authorised undertakers and 43 companies. A decision on the matter has been postponed for further consideration.

* *Fourth Annual Report of the Electricity Commissioners.* H.M. Stationery Office. [Price 3*s.* net.]; *Generation of Electricity in Great Britain.* H.M. Stationery Office. [Price 1*s.* 6*d.* net.]

NOTES.

COMMERCIAL EDUCATION.

THE Royal Society of Arts, John-street, Adelphi, is endeavouring to bring before the heads of large business establishments the comprehensive arrangements for evening instruction in commercial subjects which have been made by the London County Council. The Society hopes that employers will facilitate the attendance of their junior employees at these classes, and encourage them to take the sessional examinations. A number of firms in the London area are already doing this. Special importance is attached to regular attendance, and

hence overtime should not be asked for on class nights, and it is suggested that where students obtain certificates, the firms employing them might agree to refund the amount of the fees. The Society state that as matters stand too many young people are reluctant to pursue their education after leaving school, and do not realise their mistake till after the lapse of years. Pamphlets describing the courses provided can be obtained on application to the Education Officer at the County Hall.

Volumetric Glassware Testing.

A pamphlet, just issued by the Metrology Department of the National Physical Laboratory, gives particulars of their "Tests on Volumetric Glassware" and of the tolerances allowed. Vessels required to be correct within the class A tolerances should be submitted for "Class A Test without certificate"; when a more correct knowledge of the capacity of the vessel is desired, the vessel should be submitted for "Class A Test with certificate." For commercial accuracy the Class B Test will be sufficient. The pamphlet deals with the testing of flasks, pipettes and burettes, graduated or not, cylinders, specific gravity bottles and tubes, and vessels for gas analysis. In the case of pipettes, *e.g.*, we notice that the mark "50 ml. D 15 deg. C. (30 + 15) secs." would indicate that the pipette will, at 15 deg. C., take 30 seconds to discharge 50 millilitres and that 15 seconds more should be allowed for "draining"; during the latter period the jet should remain in contact with the side of the receiver. The Laboratory states the capacity of volumetric glassware in millilitres in preference to cubic centimetres. A litre is defined as the volume occupied by one kilogramme of water at the temperature of its greatest density and normal atmospheric pressure; the kilogramme here signifies mass, *not* the apparent weight of a kilogramme in air. The millilitre is the thousandth part of a litre; the cubic centimetre being a cube of one centimetre edge, 1,000 millilitres = 1,000·027 cub. cm. For the present, the Laboratory will accept glassware marked c.c. and will determine the capacity in cubic centimetres; but it is hoped that manufacturers will soon use the inscription ml. exclusively. On the request of the Joint Committee for the Standardisation of Scientific Glassware, the Laboratory further accepts vessels graduated in terms of G.W.A. units. The G.W.A. unit is described as a substitute for Mohr's grammes or Mohr's cubic centimetres and is defined by 1,000 G.W.A. = 1,002 ml. Vessels graduated in terms of the imperial gallons or in cubic inches are also accepted; the gallon is defined as the volume occupied by 10 imperial pounds weight of distilled water as weighed in air against brass weights, both water and air being at 62 deg. F. and the barometer at 30 in. The gallon has been legalised as 4·5459631 litres, and 1 cub. in. is equivalent to 16·38659 ml.

THE INSTITUTE OF METALS.

The Autumn meeting of the Institute of Metals was held in the hall of the Institution of Mechanical Engineers on Tuesday and Wednesday, the 9th and 10th inst. At the opening proceedings Dr. Rosenhain welcomed the visitors on behalf of the Local Reception Committee. Professor Turner, the president, announced that Mr. A. E. Seaton had desired to be relieved of the hon. treasurership; the council had reluctantly agreed to Mr. Seaton's request and had appointed temporarily in his stead Mr. John Fry. Professor Turner then voiced the regret of the meeting at the death of Sir John Beilby, a past president of the Institute. He also announced that Mr. Leonard Sumner, past president, had contributed 1,000*l.* towards the formation of the endowment fund which he (the speaker) had mentioned in his presidential address.* He expressed the hope that this would be the foundation of a larger scheme.

Internal Stress Measurements in Brass Tubes.

The first paper taken was by Mr. R. J. Anderson and Mr. E .G. Fahlmann, both of the United States on "A Method for Measuring Internal Stress in Brass Tubes." It was read in abstract by Mr. W. M. Corse.

It described a new method for the quantitative estimation of longitudinal internal stress in tube shapes—for example, cold-drawn brass tubes. It showed that the major stress was longitudinal, and the stress in the outer part of the wall of the tubing was a longitudinal tensile stress, while that in the inner portion was a longitudinal compressive stress. The summation of the balanced stresses was zero. Absence of circumferential stress in tubes was indicated by the failure of diametrically cut rings to spring in or out on being slit in two. Experiments showed that the usual testing methods which had been applied to bars and rods for the estimation of stress were not applicable to tubes, especially where the bulk of the stress was longitudinal. The method described for measuring longitudinal internal stress was called the strip method, and was carried out by slitting a narrow strip longitudinally in a piece of tubing—for example, a strip 2·75 in. long and 0·10 in. wide in a 3·25 in. tube length—and then releasing one end of the slit strip by cutting. Stress was indicated by the springing out of the freed end and could be calculated by a formula based upon the modulus of elasticity of the material and the distance in movement of the freed end. The method gave the amount of internal stress in cold-drawn tubes, and the effect of a low-temperature anneal upon stress release. It had often been thought that because cold-drawn brass did not crack on application of an accelerating cracking agent it was free from internal stress. The strip method was applicable for the quantitative estimation of stresses inferior to those necessary for cracking under the application of mercurous nitrate.

Professor K. Honda said the method was not new in principle, and was one of interest to engineers and metallurgists. What the authors measured was an average stress along the length of a tube. There were also local stresses, in tension and in compression intermixed, and in every small part of the tube. There occurred a great reduction of area by cold work, and some part might undergo a little greater elongation than a neighbouring part; then the former part underwent tension and the latter compression. What was measured was a differential effect, yet no method was available to measure the absolute internal stress in a cold-worked specimen or in a quenched steel. As an illustration he gave the martensitic structure of quenched steel. Martensite by rapid cooling underwent great local internal stress, some crystals were in tension, some in compression, and others neither under tension nor compression. Hence, in certain groups of crystals the lattice constant increased a little and in others it decreased, the amounts depending upon the intensity of the stress. There were also groups of crystals whose lattice constant remained unchanged. The aggregate of crystals gave rise to the diffusion of X-ray spectrum lines. By measuring the range of diffusion of the lines by an accurate photometric method the maximum internal stress could be estimated. This same method could also be applied to a cold-worked specimen. It was usual to explain the diffusion of the spectral lines by supposing that each individual needle-shaped crystal of martensite consisted of a very large number of fine crystals, whose linear dimensions contained only a few hundreds of atoms; but this explanation did not agree with the result of microscopical investigation. Professor Honda explained on the blackboard how a metal and its density varied by cold work.

Dr. Rosenhain thought the authors could not arrive at the real stresses in the material by the method they described. The longitudinal strip they found in a tube had a transversal curvature which complicated the calculations. The springing out of the strip cut in the tube was significant, and what it meant would have to be investigated. He (Dr. Rosenhain) also said the lattice constants and the diffusion of the X-ray spectrum was not the method to use. In pure metal, by diffusion, one could arrive at the distortion of the lattice. Diffusion, however, in the present instance was not regular throughout, there was not a uniform expansion and contraction of the lattice, and accurate measurements were difficult. He differed from the last speaker in his remarks on X-ray examination in the case under consideration, and in his statement to the effect that the atoms were closer together when compression of the metal took place in the ordinary way.

Professor Turner said, what was interesting to find out by tests was whether a tube would be safe for a number of years. If an acceleration test revealed cracking of a tube, it could be anticipated that the tube would have cracked sooner or later in service. The authors' conclusion to the effect that because a wrought brass did not crack under the application of an accelerating cracking agent, it did not follow that the material was free from internal stress, was one which he found correct. The authors' method appealed to him as a useful and practical second test, giving information which the ordinary tests did not reveal.

Nickel for Coinage.

The second paper dealt with "Experiments on the Working of Nickel for Coinage," by Sir Thomas K. Rose and Mr. J. H. Watson. It was read in abstract by the latter.

The experiments were made in order to determine the conditions in which nickel for coinage could be cold-rolled in the existing rolls at the Royal Mint. It was found impossible to prepare coins containing 99 per cent. nickel with 1 per cent. of manganese, magnesium, carbon, iron, silicon, &c., such as are manufactured with the aid of hot rolling. By the addition of 2 per cent. manganese, however, castings could be prepared suitable for cold-rolling and conversion into coin. The carbon must not exceed 0·2 per cent. and the bars should be not less than 1 in. thick and 2 in. wide. The maximum crucible charge tried was 100 lb. Mond nickel with the addition of not more than 50 per cent. of scrap made a suitable charge. Four annealings were necessary—two at 800 deg. during rolling, and one at 675 deg. after rolling and before cutting. The blanks were also annealed. Air was excluded during annealing. The blanks were cleaned before striking by being rumbled in a wooden drum with half their weight of nickel pellets in a 2½ per cent. acetic acid solution for half an hour. The coins consisted of a solid solution, and accordingly resisted tarnishing and corrosion equally well with those containing 99 per cent. or more of nickel, such as were in circulation abroad. The two kinds of coin were indistinguishable in appearance, were similarly magnetic and equally hard and resistant to abrasion. They appeared to be similarly suitable for circulation.

Mr. W. R. Barclay appreciated the work of the authors on nickel-manganese which would be useful to the industry quite apart from coinage.

Dr. F. Johnson, with reference to the high iron content, which, the authors stated, was probably derived mainly from the moulds and the rolls, expressed the opinion that this view of theirs seemed improbable and asked for more evidence on the point.

Dr. Rosenhain referred to the author's use of glass as slag. This had been used with success at Teddington and also with the melting of nickel, but laboratory selected scrap glass was taken. There were various grades of glass and careful attention should be paid to that used for such a purpose.

Sir Thomas K. Rose, in his reply, said they had not yet much evidence as to how the iron had been derived. Iron crept in continuously in increasing percentages. He thanked Dr. Rosenhain with regard to the selection of the slag forming glass.

Corrosion.

Dr. Bengough then gave a brief abstract of the "Seventh Report to the Corrosion Research Committee of the Institute," which he contributed together with Mr. R. May.

The Report considered the problem of corrosion largely from the point of view of the "Scale" of corrosion products which soon forms on the surfaces of such metals as copper, zinc aud brass immersed in sea-water. An account was given of the more important reactions which led to the production of these scales, and of the way in which they were affected by changes in the conditions surrounding the metal and in the composition of the metal itself. An important feature of the Report was

* See Engineering, vol. cxiv, page 344.

the study of the behaviour of high-speed streams of aerated sea-water in glass and brass tubes and the correlation of the behaviour of such streams with local corrosion. It was suggested that a large proportion of tube failures in modern condensers was due to local impingement of aerated sea-water, and that the actual distribution of corroded tubes in condensers often supported this view. The rapid corrosion was due to the local removal of protective scale by the impinging stream. Certain types of pre-formed scale might be very resistant to this type of action, and a useful field of work had been opened up in this direction. The occurrence of "dezincification" had been found to be due, not to bad mixing of copper and zinc in the manufacture of brass, but to the absence of arsenic from tubes; even a mere trace of arsenic had been found to prevent "dezincification" in condenser conditions. The presence of arsenic, however, was by no means always desirable and in some conditions a "dezincing" tube might behave better than a "non-dezincing" tube.

Careful observations on the electrolytic method of protection of condenser tubes had tended to throw grave doubts on the utility of this process, *per se*; usually the results were negative but occasionally good results had been reported and it seemed probable that these must be due to chance secondary effects particularly of the anode products. The great difficulty with which the process had to contend in condensers was the uniform distribution of the current along the tube; most of it was short circuited to the water-boxes, tube plates, &c., which were protected in preference to the tubes.

On the theoretical side, the view was adopted that the corrosion of brass might be due to metal-ion concentration cells or oxygen-distribution cells; these might either reinforce or oppose one another according to the conditions. With high-speed water streams the metal-ion concentration cell might become the more powerful and render the metal anodic and severely corroded; deposits of sand, porous masses of corrosion products, &c., might cause oxygen distribution cells to become active and set up local corrosion, but the most rapid cases of corrosion seemed to belong mainly to the former type, Sometimes the two types of action reinforced one another, as when pits were started by oxygen-distribution effects, owing to the unequal porosity of the scale; the thin layer of scale which covered them was finally broken down by the action of an impinging aerated water-stream, and the attack was carried on by the action of a metal-ion concentration cell.

Professor Carpenter stated that this would be the last report presented to the Institute by Dr. Bengough, who had been engaged by the Department of Industrial and Scientific Research, for whom he would continue to work on the scientific side of the same problems. The Institute's Corrosion Research Committee would continue investigating the practical side. The services of Dr. Bengough would be available to the latter Committee to a reasonable extent.

Mr. U. R. Evans expressed very general agreement with the report. Direct chemical oxidation of metals—although often producing tarnishing—did not usually cause deep-seated corrosion; direct oxidation produced a layer of oxide over the surface, and this generally protected the underlying metal from the access of oxygen. On the other hand, electro-chemical corrosion might produce the insoluble corrosion product at a distance from the surface. In the electro-chemical attack of salt water upon zinc, for instance, the anodic product was zinc chloride, and the cathodic product sodium hydroxide. Where they met they yielded insoluble zinc hydroxide by precipitation.

The necessary electric currents might be set up in at least three ways:—(1) If a noble heterophase impurity (*i.e.*, an impurity present as a separate phase) was embedded in the dominant metal, it might act as cathode, and the dominant metal as anode. Until recently this was considered the main cause of the corrosion current, but it was now believed to be comparatively unimportant. (2) If oxygen had greater access to one part of a surface than to another, currents were set up, the unaerated place being anodic and suffering corrosion. One example, the local attack of condenser tubes at places where débris had settled, had been given in the report. An instructive example was afforded by the action of salt water on iron; here the metal around the edge of the drop, to which oxygen had best access, was cathodic and suffered no attack, although marked corrosion occurred below the centre of the drop. (3) A third method was important in the case of copper. If over one part of the surface the water was stirred, and over the rest it was relatively stagnant, the stirred part became anodic, and the stagnant part cathodic. The marked local corrosion which often occurred at points of high local water-velocity near the entrance of condenser tubes was, no doubt, due to this cause, and condenser designers could do much to diminish corrosion by reducing local variations in water velocity to the minimum.

In a differential aeration cell with copper electrodes, there were—as the authors pointed out—two opposing effects. If oxygen were completely absent from one compartment and air were bubbled through the other, the aerated electrode was cathodic notwithstanding the stirring. But if a considerable amount of oxygen was present in both compartments the electrode over which bubbles were passing became anodic, owing to the stirring.

Homophase impurities (those present in solid solution) had no immediate stimulative effect on corrosion, and often (as in the case of chromium in iron) considerably reduced it. Heterophase impurities (present as a second phase) were important in setting up currents by the first method, and important for the second method also. Under some conditions it was not possible to obtain a current from a differential aeration cell unless a second metal was in contact with the dominant metal in both the aerated and unaerated compartment; it was possible that a differential aeration electro-motive force might exist in the absence of the second metal, but it was too small to overcome adverse electro-motive forces due to stirring and other causes. On the other hand, in the third method of producing local currents—important in copper—the presence of heterophase impurities was not required. In general, the influence of heterophase impurities was important in the corrosion of zinc and iron, and neglible in that of copper.

He (the speaker) had never liked the use of the word "scale" for bodies which were formed, at least in part, by precipitation. A porous corrosion product, by shielding the metal from oxygen, might actually promote local attack upon the area so shielded. But a compact corrosion product would protect the metal covered, although it might sometimes promote the destruction on the bare metal around. The complete covering up of the whole surface of an article by a protective deposit, as stated in the report, might often prove the best means of avoiding attack, but if at one point the deposit became scraped away the effect was very serious. Electro-chemical action was set up between the encrusted area, which would be cathodic, and the bare portion, which would be anodic; the total amount of corrosion would be determined by the rate of access of oxygen to the large encrusted region, but the corrosion, instead of being spread over the whole area, would be concentrated on the small bare portion, and here the linear rate of pitting would be high, and perforation soon occur.

Local corrosion was, to some extent, a combination of mechanical erosion and electro-chemical corrosion. The protective skin was, it is true, removed mechanically, but the destruction of the metal was chemical or electro-chemical. As the report showed, the mechanical qualities of the scale, and not of the metal, were important. Viewed in this way the controversy regarding whether the destruction of propeller blades was due to erosion or corrosion assumed a new aspect.

In some solutions the anodic reaction might cause the formation of a fresh protective skin over the grazed portion, and a detailed study of the conditions under which abrasions in a protective layer could "heal themselves" would be of great practical importance.

Dr. Vernon found the report of great practical value, and one which appealed both to scientists and practical men. He was specially interested in the stirring corrosion produced and gone into thoroughly by the Report. The scale adhering to metal was not necessarily protective. The experimental apparatus illustrated by the authors, to arrive at the relation between the metal-ion and the oxygen concentration effects, was of special interest to him.

Mr. T. C. Finlayson said he had been engaged on corrosion work on aluminium alloys for radiators for motor vehicles, and where he was on common ground with the authors he was in complete agreement with them. The authors' experiment to measure the difference of potential of two alloys did not yield sufficient information, or else the information was not easy to interpret. By fitting up two alloys with a millivoltmeter and a resistance the readings gave the electro-motive force, and one could arrive at the driving force of corrosion and the resistance to corrosion. Colloidal chemistry came in and he thought the authors should not have abandoned it, since some phenomena could only be explained by colloidal chemistry.

Mr. A. Marks expressed the belief that more investigation had been carried out on condenser tubes than the subject probably warranted. The corrosion of a few tubes was of little importance compared with the corrosion of the hull of a ship. The work, however, led to the scientific investigation of corrosion and enabled one to the arrive at means to protect condensers better. But one was apt to lay too great a stress on condensers as apart from the other portions of a vessel. In regard to propellers, the tendency was to say they eroded rather than corroded, but he (the speaker) had studied this particular problem and his conclusions were at variance with the mechanical theory both as to propellers and to tubes. It was easy to reduce the water flow velocity through the condenser, but this reduced the efficiency, although the reduction in flow velocity might be good from the corrosion point of view. But, he repeated, the condenser tube trouble was not comparable with the other troubles a shipowner had to face, and the corrosion of the hull and of the propeller was a graver problem. The Institute should take up the Government report on propellers and look into the question. A ship formed, as it were, a chemical system floating in probably the most corrosive agent that existed. He warned all who were protecting the condensers from corrosion to go carefully, inasmuch as the cost of replacing a few condenser tubes was not to be compared with the replacing of a whole ship plating length which corroded heavily. The cure of the condenser might be at the expense of the whole ship.

Mr. W. M. Corse gave an outline on the work on corrosion being carried out in the United States, adding that the problem was a World problem, not a national one. American researchers would be glad of an interchange of opinions between the two countries.

Extrusion of Brass.

The fourth paper had reference to "The Extrusion of Brass Rod by the Inverted Process," by W. R. Genders, who read it in abstract. We reproduce the paper on page 387 of the present issue.

Dr. R. S. Hutton said he had witnessed the demonstration with the new press after this was built and had seen it work with success. He hoped that results of the practical work of the press in India would soon be forthcoming to confirm the test results.

Effect of Iron on Copper.

The last paper taken on Tuesday was an "Investigation of the Effects of Impurities on Copper: The Effect of Iron on Copper," by Dr. D. Hanson and Miss G. W. Ford. It was read in abstract by the latter.

It showed that iron exerted a very considerable effect on the properties of pure copper; the effect of this impurity was in many respects very much greater than that of oxygen. The observed effects on the mechanical, electrical and other properties were in keeping with the structure and constitution of iron-bearing copper, as revealed by a microscopical study of this material. Solid copper dissolved 4 per cent. of iron at 1,100 deg. C., but the

solubility at lower temperatures was much less. Within the limits of solid solubility the effect of iron was considerable, particularly on the electrical resistivity, which increased rapidly as the iron content was raised; this increase was so rapid that iron must be regarded as extremely deleterious in copper for electrical purposes. When the iron content exceeded about 0·2 per cent. the effect on the resistivity depended largely on the heat-treatment of the material.

The effect on the tensile strength was less than might have been anticipated in the case of a soluble impurity and, although in this respect iron had more effect than oxygen, it still produced a relatively soft material, even when the copper was saturated with iron. The tensile strength was raised by 2 per cent. of iron from 14·5 tons per square inch to about 20 tons per square inch. The effect of heat-treatment was relatively small, in spite of the large differences in solubility of the iron, and a considerable improvement in strength as a result of heat-treatment, such as could be obtained in steel and some aluminium alloys, had been realised.

Iron had no great embrittling effect and copper containing iron could be rolled with great ease. Iron was a deoxidiser for copper, but it created difficulties during casting owing to the formation of films that destroyed the continuity of the metal. The deoxidising action was not great, as a considerable excess of iron would appear to be required to remove all the oxygen. Copper containing iron as a sole impurity was difficult to machine; it was soft, and "dragged" under the tool.

Dr. Rosenhain said this was a further step in the National Physical Laboratory's investigations of the effect of impurities in copper. In this case the metal was not a copper-iron alloy. The hardening of copper containing iron was very remarkable. The Brinel hardness was nearly double and the tensile strength was not very largely affected.

Dr. F. Johnson found specially interesting the fact that a short annealing at 700 deg. C. for thirty minutes increased the conductivity of a casting containing 0·06 per cent. of iron from 99·7 per cent. to 101 per cent., whereas a drastic annealing at 1,000 deg. C, and a re-annealing at 650 deg. C. for an hour reduced the conductivity to 91·2 per cent.

(To be continued.)

THE NEW CUNARD LINER "AURANIA."

THE Cunard Line lost during the war probably more ships than any other company, some twenty-six in all, including the Lusitania. Some of these had been purchased in order that the duties imposed by the Government might be effectively fulfilled. As a consequence, there were ordered new ships to the number of seventeen. Many have already been completed and have entered the various passenger services of the company; but when the collapse in freight rates came and the flow of passengers lessened, the company decided to stop work on several vessels. Recently, however, the shipbuilding firms were allowed to proceed with building operations. Messrs. Swan, Hunter, and Wigham Richardson have now delivered one of these liners, the Aurania, and she will be followed soon by the Alaunia, from the Clydebank works of Messrs. John Brown and Co. Ltd., the Esthonia, from the Tyne works of Sir W. G. Armstrong, Whitworth and Co., Limited, and the Servia from the Barrow works of Messrs. Vickers Limited. It may be said that the Cunard Company, when these vessels have been delivered, will have replaced all the passenger vessels lost, but at what cost? It would not be an exaggeration to say that the cost of the new ships per ton is about three times that of the pre-war price paid for the steamers they replace. In addition, some of the vessels have had to be sent to European ports to be completed, owing to the joiners and other disputes. These facts carry their own moral.

The Aurania, which sails for Canada on Saturday, had a trial from the Tyne to the Mersey round the north of Scotland last week-end. She is of special interest as she and the five other vessels of the class, are of moderate size and speed. While the passenger accommodation is thoroughly comfortable, there is no display of luxury, as such. In other words, she is what may be termed a good financial proposition. With a length b.p. of 519 ft. and overall of 540 ft., a beam of 65 ft. 3½ in. and a depth of 43 ft., she has a gross tonnage of 14,000 tons. On a draught of 30 ft. 10 in., her displacement is 21,875 tons.

She is of the two-class passenger type, carrying 520 in cabins, and 1,042 in the third class. She has a large cargo capacity and fully laden can be driven at 15 knots, with a consumption for all purposes of about 90 to 93 tons of oil per day. The arrangement of the passenger accommodation follows the now usual lines. In addition to a small lounge on the boat deck forward, the public rooms are arranged as follows, beginning at the forward end of the deckhouse on "A" deck:—Winter garden or main lounge, grand entrance with circular stairway, then on the port side, the nursery and drawing room, which latter is entered from a long gallery on the starboard side, serving as a supplementary lounge, and still further aft the smoking room and a gymnasium, each occupying the full width of the deckhouse. The promenade is around all sides of this deckhouse. A feature which is commendable is that each room has its separate entrance, and is in no sense part of a corridor connecting different rooms.

The Aurania is the eleventh Cunard liner built by Messrs. Swan, Hunter, and Wigham Richardson including the Mauretania. She is the third of the same name. They have all been engined by the Wallsend Slipway and Engineering Co., Limited, but it is equally interesting to note that Mr. Andrew Laing, the managing director of this company, has been responsible for the construction of the machinery for nineteen Cunard liners at Fairfield and Wallsend. The machinery of the Aurania consists of two sets of double-reduction geared turbines of the Parsons impulse and reaction type, each driving a propeller. The turbine construction follows normal design, with the condenser located under the turbine. When working at full power—8,500 shaft horse-power, when the service speed will be 15 knots—the propellers will run at 90 revolutions per minute; but the h.p. turbines will make 3,193 revolutions and the l.p. turbine 2,171 revolutions, the reduction, as stated, being by double gear. The condensers by Messrs. Weir, have a cooling surface of 4,250 sq. ft. each, and the closed feed water system is adopted. Steam is supplied by four double-ended and two single-ended boilers, having a total heating surface of 20,262 sq. ft.

Superheaters are used to give 200 degrees, and the working pressure is 220 lb. The double-ended boilers are 17 ft. 6 in. by 22 ft. 6 in. and the single-end boilers 17 ft. 6 in. by 11 ft. 6 in. This arrangement has been adopted as one single-ended boiler suffices for all harbour duties. As with the ship, the auxiliary machinery conforms to the highest standard of British marine practice.

LABOUR NOTES.

THE opinion of the movement's responsible men seems to be that the amendment to the standing orders passed by the Hull Trades Union Congress on the proposal of the General Council, will have the effect of lessening rather than increasing the number of stoppages of work through disputes—with employers or differences between unions. Where unions refuse its assistance or reject its advice, the General Council is empowered to report to that effect to Congress, which will then, presumably, proceed to discipline the rebellious organisations. At first sight, that seems to be an advance on the practice hitherto obtaining. In fact, however, it is not, as more than one union—notably the old Amalgamated Society of Engineers—have, in the past, declined to be disciplined for "offences" of this character and ceased to be affiliated. Where unions in dispute with the employers of their members accept its assistance and advice, the General Council now has the power to organise all necessary moral and material support on their behalf. The more militant trade unionists appear to regard that part of the addition to the standing orders as something which may be used effectively—in the "fight against Capitalism." Moral support may be effectively organised, but material support is a totally different matter. Under the rules of most of the craft unions, no strike, sympathetic or otherise, can take place without a ballot of the rank and file. Nor, until a ballot vote has authorised it, can a levy for any purpose be taken. Wisely used, the new powers of the General Council can achieve much good, but it is a mistake to assume, as is being done, that they over-ride the constitutional authority of the affiliated unions.

The "Industrial Workers' Charter," which was passed unanimously by the Congress on September 3, is a mixture of politics and economics which, no doubt, accurately expresses the aspirations of Labour's rank and file. Participation by the workers in the control of industry and its management does not seem to be the kind of thing demanded by the leaders of the National Minority Movement. What these extremists desire is, absolute control by the workers in the interest of the workers. To that extent, therefore, the "charter" will probably be regarded by them as reactionary. But in respect of its demands for a 44-hours' week and a legal minimum wage, the framers and approvers of the "charter" shut their eyes as tightly to economic facts as the most extreme of the extremists regularly do. An international 44 hours' week and legal minimum wage might do no harm, but with Great Britain's principal rivals working longer hours for lower wages, it is not unreasonable to assume that the "charter" conditions would be a fatal handicap to British industry—even to British industry re-organised as the extremist desire to re-organise it.

The *Railway Review*, which is the organ of the National Union of Railwaymen, thinks that instead of a "maximum working week of 44 hours," that line in the "charter" should be "a standard working week of 44 hours," because in occupations such as railways there are occasions when men cannot possibly be relieved at the expiration of the normal working period of duty. Unlike factories and workshops, in order to meet the general convenience and requirements of the public, the writer says, railways have to operate continuously throughout the 24 hours, Sundays and weekdays, and it is, therefore, quite impossible to treat a railway as though it could be closed down at a given moment. Train delays are, moreover, not infrequent, consequent on fog or other weather conditions, rushes of traffic, breakdown of apparatus or other mishaps, train connections at junctions, and other causes. These delays are liable to occur, it is pointed out, when railwaymen could not possibly be relieved from duty precisely at the end of the normal shift, the expiration of which might find them at a place miles away from where relief staff was available. It should suffice to say, it is contended, that the normal or standard working day and week should be, respectively, so many hours. It could then be safely left to the railway trade unions to see that excessive hours were not worked, and that every man was afforded adequate rest intervals between shifts of duty, and was paid at enhanced rates for any time worked beyond the standard day and week.

An award of more than ordinary interest was issued by the Industrial Court last week. The parties to the reference were the National Union of General and Municipal Workers and Messrs. Nevill Druce and Co., Limited, copper and yellow metal refiners and manufacturers, Llanelly, and the point which the Court was asked to decide was whether the firm as the result of their trading as and on April 1, 1923, were in a financial position to consider an advance in wages. An application for an advance in wages had been made by the union for 310 out of 410 of the firm's workpeople, and no agreement having been reached, the case was referred to the Court. The union submitted that the present rates of pay were insufficient in view of the cost of living, and especially in view of the burden of weekly rents which were equivalent to about one-fourth or one-fifth of the weekly wages. On behalf of the employers, it was contended that the company had only two cottages and were not otherwise responsible for the rents payable by the workers. It was urged that the result of the trading for the year commencing April 1, 1923, made it impossible for the company to consider the question of an advance of wages. The unsatisfactory result of the year's trading was attributed, by the company's representative, principally to the effects of foreign competition, especially in the yellow copper export trade to India, and also to the high price of coal. The Court decided that, as a result of their trading as and from April 1, 1923, Messrs. Nevill, Druce and Co., Limited, were not in a financial position to consider an advance of wages at the present time.

A conference took place at Edinburgh on Thursday of last week between the Executive Committee of the Shipbuilding Employers Federation and the Executive Council and other delegates of the Ship Constructors' and Shipwrights' Association for the purpose of considering certain points relating to working conditions, and also a number of anomalies, which the men contend have arisen in the application of the Overtime and Night Shift Agreement. After a lengthy exchange of views, the conference was adjourned, to resume at an early date.

The Minister of Health has appointed a committee to inquire and report as to new materials or methods of construction which are, or may be, available for the building of houses for the working classes, and to make recommendations as to the organisation required for securing the adoption and use of approved new materials or methods, by local authorities and other bodies or persons providing such houses. The committee is to be constituted as follows:—Sir Ernest W. Moir, Bart., (chairman), Sir Frank Baines, Sir Charles T. Ruthen, Major Harry Barnes, Mr. John A. Brodie, Mr. R. Coppock, Mr. E. R. Forber, Mr. G. Hicks, Mr. H. J. C.

Johnston, Lieut.-Col. Cecil B. Levita, Mr. W. H. Nicholls, Mr. A. G. White, Mr. C. E. Whyte, and Mr. J. Wilson. The secretary is to be Mr. T. H. Sheepshanks.

Conversations took place in London last week on the subject of the seamen's working day between M. Leon Mayer, Under Secretary of State for the French Merchant Marine, and Mr. Sydney Webb, President of the British Board of Trade. According to M. Mayer, they agreed upon a formula which is to be submitted within a fortnight to a committee of British shipowners and seamen. If it is then approved, a conference is to be called of all the nations represented in the International Labour Bureau, which will be invited to adopt the formula as an international agreement.

The report of the National Union of General and Municipal Workers for the first half of the current year states that the paying membership of the organisation is 220,740, and that the funds in hand amount to 210,900*l.* The secretary, Mr. W. Thorne, M.P., mentions that the union now numbers amongst its members 13 members of Parliament, three of whom are women, and two are members of the Government. "No other single union in the country has," he claims, "this noteworthy distinction."

Russian Information and Review states that the Union Commissariat for Labour has issued regulations whereby those lacking the means of existence are allowed deductions or exemption from the payment of rent and taxes and for various municipal services, such as water supply, &c. The right to such privileges is entirely independent of whether the recipient is registered at a labour exchange. The only condition made is that the applicants must really be in need and that, having been a wage worker, he or she does not, at the time of application, enjoy an additional income from trade, industry or farm, or is not being supported by people who have an independent income or salary. The degree to which the applicant is in need and has a right to the privileges indicated is determined either by special investigation of his, or her, social and material position, or by a special certificate on this subject from his or her trade union, or in the case of citizens who are not trade union members, by a certificate from the administrative boards of their respective Housing Associations or District Housing Committees.

A national conference on unemployment, which met last week in Toronto, decided against the payment of doles, and urged the Federal and Provisional Government to call for tenders and to begin all public works for which grants have been passed. It also recommended that shorter hours should be worked in order to spread the available employment over a larger number of men. According to the *Times* correspondent, a national committee is to be set up to survey the whole field, and to determine where work can be found. The committee is to consult with the various governing bodies as to ways and means of financing such undertakings. Where unemployment exists, it was suggested, a definite understanding should be reached between the various official bodies concerned, and emergency relief should be provided, 50 per cent. of the cost of which should be borne by the local authorities and the remainder in equal proportions by the Federal and Provincial Governments. Another recommendation agreed upon was that steps should be taken to induce the Provisional Governments to maintain advisory unemployment services, for which grants would be provided by the Dominion Government.

Sir William Mackenzie has sustained a claim of the Constructional Engineering Union for workmen's travelling expenses which, at first sight, did not seem to be too well founded. The other party to the reference was the Bridgebuilding and Constructional Engineering Employers' Association (Lancashire and Cheshire District) acting on behalf of Messrs. Lambourne and Co., of Manchester. Messrs. Lambourne are engaged under contract on steelwork erection at Cheadle Heath, and nearly all the men employed by them there were engaged "on the site." Some of them lived in Stretford, some in Manchester, and others in Salford and elsewhere, and the Union claimed on their behalf a sum in respect of local travelling expenses. The matter was governed by Article 9 of a decision of the Industrial Court, given in 1920, which provides that in the case of men returning home each night "certain payments in respect of travelling between a central point (to be agreed upon) and the site of contract" shall be made. The Union contended that St. Ann's Square, Manchester, was the "central point" agreed between the parties, and that each man was entitled to 1*s.* 6*d.* per day. The Employer's Association held that the provision for local travelling expenses did not apply to men taken on "at the site." Sir William Mackenzie held that the only qualification required of the men under Article 9, to entitle them to travelling expenses, was the fact that they returned home each night. If they did, the distance of the site of the contract from the "central point" determined the amount, if any, to be paid. The article did not, Sir William said, introduce any other qualification, such as that the men must be sent from the works, nor did it exclude men taken on at the site. The "central point" was one that had to be determined from time to time, according to the situation of the site. It was not a fixed point but a movable one. If St. Ann's Square, Manchester, had been agreed as the "central point" the Union were right in their claim.

On the recommendation of its Tramway's Committee, Manchester City Council has, by a narrow majority, decided to give a contract for steel rails of the value of 8,375*l.*, to American manufacturers. At the same time, it resolved to place a contract of the value of 6,950*l.* for similar material, in Sheffield. The contention of the minority was that the whole of the order for rails should be executed in this country. Interviewed afterwards, Alderman Tom Fox, a former Labour Lord Mayor of Manchester, who declared that he was "neither an idolatrous Free Trader nor a stubborn Protectionist," said that he regarded it as altogether wrong to send such a contract out of the country at a moment when unemployment was tending to increase. "I am anxious," he went on to say, "about the thousands of our men and women who cannot find jobs. It seems like wilfully stultifying ourselves to send orders abroad, when firms supplying this very class of rails at Barrow and Sheffield are closing down their works for want of orders. We can buy the best class of steel rails in this country. Private individuals would, it is contended, buy in the cheapest market. Some might," the Alderman admitted, "but municipalities with responsibilities to the public cannot afford to do so."

The Ministers of Labour of Belgium, France, Germany and Great Britain met at Berne on September 8 for the purpose of considering "the practical international application of the principle of the eight hours day on the basis of the Washington Convention." The Ministers "were glad to find," it is officially stated, "that on most points their views coincided entirely, and that where differences existed they were not considerable." The conference "closed with the unanimous feeling," it is added, "that common ratification of the Convention is possible." Judging from the reports submitted to the Metalworkers' International and the Textile Workers' International, other countries besides Germany have working days that are in reality much longer than eight hours. But at Berne it seems to have been assumed that the chief obstacle to international application of the Washington Convention was Germany.

According to the *Times* correspondent, Herr Brauns, the German Minister, made it clear that he could accept nothing which implied any sort of foreign control over German economic legislation; but he was assured that the position of all the countries signing the Convention would be exactly the same. If doubts are felt by any country as to the efficacy of the application of the eight hour day in another, it may lodge a complaint with the Governing Body of the International Labour Office, which, if it considers the complaint well grounded, may enquire into the matter. Ultimately the complaint may have to come before the International Court of Justice. Reassured on this point, the German Minister agreed to recommend ratification of the Convention by Germany and expressed confidence that his Government would shortly rescind the order of December, 1923, extending the working day beyond eight hours in certain industries. The result is assumed to be a success for the International Labour Office. Obviously, however, unless there is provision for the simultaneous application of the Convention, without any modification or qualification, a real danger to British industry will arise, if our Government persists with its Bill to ratify the Washington bargain. An industry might easily be irretrievably ruined while the prescribed appeal procedure was being followed.

The special tribunal, which has been set up to examine and report upon the facts material to the issues between the employers and the workers in the electricity supply industry, arising out of the application of the men for an advance in wages of 10*s.* per week, began its sittings on September 10. At the outset of the proceedings, Mr. W. Addington Willis, the chairman, explained that the tribunal was not a Court of Arbitration to determine finally the matters at issue and make an award; nor was it, he said, a Court of Inquiry set up by the Minister of Labour under the Industrial Courts Act for the purpose of reporting to him after investigation. It was a tribunal set up by the National Joint Industrial Council for the electricity supply industry, and constituted by it, in order that all the members of the council might have knowledge of the facts and issues before they arrived at a final decision on the matter in dispute.

At its last meeting the National Committee of the Amalgamated Engineering Union recommended the imposition of a levy of 6*d.* per week to provide for the payment of half-donation benefit to discharged unemployed members. The proceeds would, it was pointed out, enable the executive to enter into an arrangement with the Ministry of Labour for the payment of State unemployment benefit through the branches. The ballot, which it was necessary to take on the subject, has, however, rejected the proposal by 26,716 votes to 19,481.

The *A.E.U. Monthly Journal* for September states there was an increase of 1,300 in the number of unemployed members in August. The total is now 20,112 or 8·75 per cent. The membership of the organisation has decreased from 253,355 to 253,264.

On September 1 there were 1,162,700 unemployed persons on the registers of Employment Exchanges in Great Britain—869,200 men, 40,900 boys, 218,000 women, and 34,600 girls. The total is 13,632 greater than the figures for August 25, but 122,923 less than the figures for December 31.

SOUTH WALES AND MONMOUTHSHIRE SCHOOL OF MINES.—The calendar of the South Wales and Monmouthshire School of Mines for the session 1924-25 has just been published, and contains particulars of both full-time and part-time courses of instruction, available for colliery students. Time-tables of courses are included, together with information relating to scholarship and post-diploma work. These classes are given at both Treforest and Crumlin, and all inquiries should be addressed to Mr. Hugh M. Ingledew, 4, Mount Stewart-square, Cardiff.

NEW SPANISH NAVAL CONSTRUCTION.—The new light cruiser Mendez Nuñez has just completed her trials, and will shortly be placed on the Spanish fleet list. Her characteristics are: Displacement, 4,725 tons; length, 462 ft.; beam, 46 ft.; draught, 13 ft.; speed, 29 knots; i.h.p., 45,000; armament, six 5·9-in. guns and four 4·2-in. anti-aircraft guns. The Mendez Nuñez was built by the Sociedad Española de Construccion Naval, and has been named after the Spanish admiral who bombarded Valparaiso and Callao in 1866. The centenary of his birth has recently been celebrated throughout the Spanish navy.

CANADIAN MINERALS.—In connection with the British Empire Exhibition, the Canadian Pacific Railway Company has issued a series of leaflets dealing separately with the situation of the several industrial resources of the Dominion, on the latest available information, mostly for 1923. In addition to the leading facts in regard to the properties and sources of the substances in question—mostly minerals—these leaflets contain a considerable amount of information as to production, course of prices, Canadian and United States tariffs and applications; in many cases with names of the principal operators in the industry. They present in a convenient form the chief information that would be wanted by those interested in the minerals in question, and further information is offered on application to either the Company's development engineer in Montreal, Mr. A. E. Moore, at 62-65, Charing Cross, or any of the Company's representatives at the Exhibition. In our recent article on the Canadian Pavilion (p. 137, *ante*), reference was made to the variety and extent of the Dominion's industrial resources, and the particulars given in these leaflets furnish a useful amplification of those there given. The resources dealt with in these leaflets include water power, natural gas, peat, bituminous sand and coal, as well as all the metallic and non-metallic minerals that are worked industrially.

CEMENT MANUFACTURE WITHIN THE EMPIRE.—In many overseas countries, particularly those remote from the present centres of production, the use of cement is greatly restricted owing to the heavy cost of shipment and the consequent high price of imported supplies. Portland cement is already being made in large quantities in several countries of the overseas Empire, such as Canada, South Africa, Australia, New Zealand and India, whilst operations on a smaller scale are being carried on in the Sudan, Rhodesia, and Malaya. It seems probable that the raw products required for cement manufacture exist in nearly all parts of the Empire, but hitherto little information has been available regarding the possibilities of establishing a cement industry in most of the Crown Colonies and Protectorates. Considerable attention has been devoted to this question in recent years by the Imperial Institute, and the current number of the "Bulletin of Imperial Institute" contains an outline of the properties of cements and particulars relating to manufacturing possibilities in the Crown Colonies and Protectorates. In the first part of the publication British West Africa is dealt with. It is shown that Nigeria possesses the necessary materials for cement-making, as well as coal and lignite. Suitable limestones occur on the Gold Coast, but Sierra Leone does not seem to have the resources for cement-making.

AGRICULTURAL ENGINEERING EXHIBITS AT THE BRITISH EMPIRE EXHIBITION.

THE decision of the Agricultural Engineers' Association not to take part in the British Empire Exhibition has resulted in the agricultural industry of Great Britain being almost entirely unrepresented at Wembley. With the exception of three firms of general engineers who have allotted a portion of their stands to the display of an agricultural exhibit, no agricultural machines or implements are shown in the Palace of Engineering. The display of motor cars and accessories invite comparison with a similar collection of agricultural machines and implements which could have been shown, and inquiry amongst the demonstrators of the car section revealed the disappointment of many visitors at not seeing a representative show of the engineering appliances which serve what is still the largest industry of Great Britain. Although this failure to exhibit is a matter to be deplored, it must yet be realised that manufacturers of agricultural machines and implements are compelled to spend a considerable amount of money to exhibit their wares at the numerous agricultural shows taking place throughout the year in every part of the country.

The model power farm constructed by the Leeds Model Company to the direction of the Research Branch of the Ministry of Agriculture and Fisheries may be called the only composite collection of agricultural machines and implements shown at the Exhibition. Considerations of space have caused the models to be constructed on a very small scale, and the size of the fields are much smaller than they should be in comparison with the machinery and farm buildings. This model serves to represent the ideal use of power on the farm and affords an example of its use for practically every operation and in every season. It has been divided broadly into the application of power in house, barnyard and field. Methods of cultivation are demonstrated by a model of the well-known Fowler and McLaren system of cable haulage, and a balanced multi-furrow plough is used. As the model is intended to demonstrate the use of power on the farm, horses are consequently entirely eliminated, and every field operation demonstrates the use of tractors. It is worthy of note that many farmers of to-day regard the tractor as an indispensable adjunct to most farming operations, and many more would purchase tractors at the present time if they could secure drivers with sufficient knowledge of internal combustion engines to keep them in running order and to avoid the abuse to which so many tractors are commonly subjected. The model serves the purpose of demonstrating to farmers some of the numerous operations which can be performed.

A tractor is shown drawing a mole draining plough, an implement used to make circular drains in heavy clay soils. This is an operation for which the tractor is particularly suitable as the draught is too heavy for a convenient number of horses. Until recently mole ploughs were only employed with steam tackle sets, but miniature mole ploughs to be drawn by tractor have now been invented, and produce very excellent results. A further implement used with a tractor is a subsoiling plough. Beneath the ordinary depth of ploughing is often found a "hard pan" or solid stratum of soil which adversely affects the growth of crops. This "hard pan" is disrupted and not brought to the surface by means of a subsoiling tine attached to the plough. This is an operation which can be done by horses, but the number of hours of work possible is limited, whereas a tractor can work continuously and also subsoil to greater depths. Tests conducted during recent years with subsoiling ploughs drawn by tractors proved that an increased yield was obtained in all cases, amounting sometimes to as much as 60 per cent. This increased yield was chiefly due to the assistance rendered by tractors. Tests conducted last year also showed the efficiency of tractors for hauling harvesting machinery, and many farmers keep a tractor solely for work during harvest. Tractors are shown in the model hauling a mowing machine, a self-binder, a hay loader, and also driving a threshing machine. The tests previously referred to showed that a tractor was most economically employed when hauling two or more machines, but the limitations of space in the model have prevented more than one machine being used in every case.

The machinery barn has a portion of its roof removed to show the machinery contained. An electric motor drives the shaft from which the various machines obtain their power. A metal "Economic" silo manufactured by Messrs. G. H. Gascoigne and Co., Reading, is displayed. The silo is used for preserving green fodder in a succulent condition for winter feed and is charged by a cutter and blower furnished by Messrs. E. H. Bentall & Co., Ltd., of Heybridge, Maldon, Essex. The silo, constructed from either metal, concrete or wood, is being largely adopted in this country.

On the power house is shown a windmill for generating electricity. This is supplied by Messrs. Telford, Grier and Mackay, Limited, of Glasgow. The full-sized windmill represented by the model, generates electricity by means of a generator coupled to the wheel through gearing, and the generator "cuts in" at low speeds and "cuts out" when the wind speed becomes excessive. Tests will be conducted shortly upon this and other types of mills by the Institute of Agricultural Engineering, Oxford University, to determine the efficiency and economy of windmills used for this purpose.

A circular stack is shown with a section cut away, to demonstrate the system employed to dry crops in the stack. Experiments are still proceeding in which grass or other crops are built into a stack around a central chamber shortly after cutting, and the surplus moisture removed by means of a blast of air circulated by a power-driven fan. The system is directed to save many of the costs of harvesting operations subsequent to cutting, and also to insure that crops may be harvested irrespective of unfavourable weather conditions.

Rothamsted Experimental Station enjoys a wide reputation for the experimental work in agriculture conducted there. The Soil Physics Department for some years past has been investigating the subject of tilth—the criterion by which all cutivating methods must be judged. The exhibits include a plough breast made by Messrs. James and Frederick Howard, Ltd., Britannia Iron Works, Bedford, and, with several glass bricks placed along the length of the breast, the furrow-turning motion of a plough is demonstrated. A small circular track turned by hand demonstrates the production of tilth by the successive actions of the plough, harrow, roller and frosts. The plough first turns the furrow, the harrow breaks up the furrow and the roller crushes any clods which may be left and leaves a regular surface to the field. Given these cultivating conditions it only remains for the disintegrating effects caused by frosts to complete the production of tilth.

A further exhibit is the self-recording traction dynamometer, specially designed by Mr. G. Watson, M.I.A.E., for use in the tractor trials two years ago. This instrument has been exceptionally useful, in researches into cultivating machinery, and can be regarded as almost indispensable in the equipment of an implement designer. It serves to measure drawbar pull, distance travelled, depths ploughed and time occupied. It was described in our issue of June 30, 1922, p. 814.

Near the Government Pavilion may be seen an up-to-date cowshed, arranged by the National Federation of Dairymen's Associations. The equipment shown includes machinery for cooling, bottling and pasteurising, manufactured by Messrs. Arthur G. Enock, Ltd., and illustrates the great advances made during recent years by British firms to capture a market which has hitherto been chiefly foreign.

The electro-farming exhibit arranged for the British Electrical Development Association by Mr. R. Borlase Matthews, is of particular interest to the farmer at present, owing to the proposals contemplated by the Government for the extension of electric supply from main towns into urban and rural districts. This exhibit is situated near the Government Pavilion, and may be located by the windmill with "Electric Farming" painted on its vane. The windmill manufactured by the Glasgow Electrical Engineering Company, generates electricity by means of a generator driven through bevel gearing. Provision is made for "cutting in" and "cutting out" when the wind-speed is low or too high respectively. A very simple form of tower is used, consisting of a singular tubular rod, 40 ft. long in this case, supported by adequate guys. The whole unit is essentially simple, and designed to call for the smallest possible attention by the owner.

The remaining exhibits demonstrate the application of electricity to particular groups of agriculture. Milking machines, separators and churns are shown working in the dairy; barn-yard machinery is driven by an electric motor; water is pumped by electricity, and electrical sheep-shearing equipment is also displayed. A further interesting exhibit is a straw rope-making machine of suitable size for use by ordinary farmers. This machine should go far to solve the problem of the disposal of surplus straw, and should enable manufacturers in this country to be independent of foreign straw rope supplies. It is satisfactory to know that if ever electricity supply is available throughout the country, there exists an organisation, which, by its past experience, can provide farmers with assistance to take the fullest possible advantage of the new form of power placed at their disposal.

Messrs. John Fowler and Co. (Leeds) Limited, show a compound type steam ploughing engine in the Palace of Engineering. This company has had experience of steam cultivation over many years, and the system of cable haulage evolved by them is universally used. Most sets of steam tackle in this country are owned by contractors who travel from farm to farm performing work at charges which are fixed for the particular area. The latest model displayed at the exhibition is in every way a worthy successor to the previous models which have created such a high reputation. The boiler is constructed for a working pressure of 180 lb. per square inch, and the engine is fitted with duplicated injectors, and employs a mechanical "Manzel" type cylinder lubricator. The arrangements for dealing with the cable offer the greatest difficulties in this system, but they have been successfully overcome by the aid of several ingenious devices. The winding drum, driving gear, ploughing gear and shaft brackets are all of cast steel; the drum carries 600 yards of cable, and a brake is fitted on the ploughing clutch (operated by the driver from the footplate) to prevent the slack rope dropping when the opposite engine has completed its pull. The pawl catch for the brake is automatically lifted out of engagement when the engine is winding.

This company, although so intimately connected with steam practice, has not failed to appreciate that the internal combustion engine has made great headway during recent years, and in some cases provides facilities unobtainable with steam engines. This realisation of changing times takes concrete form in the shape of a 70-h.p. motor cable ploughing engine. The engine is typical of the application of steam cable ploughing experience to internal combustion engine practice. A four-cylinder engine of the heavy-duty type is fitted, and a novel arrangement is made whereby the main engine is started by a single-cylinder air-cooled engine with the aid of friction discs in contact with the flywheel. This is an arrangement which will be appreciated by all who have endeavoured to start up heavy internal combustion engines in the field on a cold morning. The carburettor is suitable for either petrol or benzol, and special vaporisers can be fitted for use with paraffin or alcohol. A four-furrow anti-balance plough manufactured by Messrs. Howard, of Bedford, for cable haulage is shown on the Fowler stand.

In the motor section of the Palace of Engineering under the auspices of the Society of Motor Manufacturers and Traders may be seen an Austin tractor, and a "Yorkshire" steam power farmer. It is a regrettable thing that the majority of the agricultural tractors used in this country are of American manufacture, and it is satisfactory that an English firm still maintains its hold on the market. The Austin tractor, which is rated at 25 h.p., achieved very good results in the tractor trials conducted during recent years, and the manufacturers have

shown their appreciation of the necessity of making it a general utility machine, by preparing special wheels with rubber tyres which can be fitted for road haulage. It is understood that a special three-wheeled Dobby cart with a tipping end is manufactured specially for haulage purposes, but this is not shown at the Exhibition.

The "Yorkshire" steam power farmer marks an incursion of the Yorkshire Patent Steam Wagon Company of Hunslet, Leeds, from road haulage into the sphere of agriculture. The machines are designed for cable haulage on the double engine system and embody a fire tube boiler with superheater similar to that used in their road transport wagons. The engine is a vertical compound balanced, with reversing gear, indicating 50 h.p.; the machine is very solidly constructed and a pulley wheel is conveniently placed. The cable anchorage and winding gear are very well designed. There are several interesting models shown in the India (Bengal) section of natives using wooden ploughs.

In the Australian Pavilion are shown some agricultural machines, manufactured by Messrs. H. V. McKay (Proprietary), Limited. The first of these is a Sunshine harvester which collects and threshes the grain in one operation. It is hoped that some tests of this machine may be conducted next season. The machine is pushed through the corn by horses or a tractor and the heads are stripped from the straw by means of a comb at the front of the machine. It is interesting to note that this is a return to the original harvesting methods described by Pliny as in use on large estates in Gaul in the first century. The heads of corn so collected in the Sunshine harvester are conveyed by two archimedian screws to a miniature thresher which forms an integral part of the machine, and the clean grain is deposited in sacks. It is doubtful whether the machine will enjoy much popularity in Great Britain, as by its use the straw is not collected, and also the corn must be dead ripe when the machine is used, a condition not favoured here. The Sunshine harvester with the aid of an engine may be used as a stationary threshing machine. A "Suntyne" drill made by the same company is also shown. The feature of this drill is the great number of spring tines employed to pulverise the top soil to obtain a good tilth. The drill makes it apparent that seed beds are not so well prepared in Australia as in this country.

In the same pavilion are shown Trewhella monkey jacks and winches for timber clearing. The jack, which is worked by hand, is of the well-known rack and bar type in which the casing is made to move up and down the pillar instead of remaining stationary. The casing carries two lifting claws fitted at different heights and on opposite sides, the top claw being at a convenient height to go under a load which the bottom claw has raised to its limit. The working range of the jack may be increased by fitting spears of different lengths. The mechanism of the monkey winch does not depart greatly from the ordinary winch fitted with a ratchet gear, except that the steel rope is specially adapted for holding and pulling timber. Tests conducted with these two devices two years ago proved them to be efficient and more economical than hand labour when large tracts of land had to be cleared. An article of this kind must close with a note of regret that visitors to the Exhibition are offered no opportunity to gain any worthy impression of the great agricultural engineering industry of this country.

INTERNATIONAL FOUNDRY TRADES EXHIBITION, BIRMINGHAM, 1926.—The Birmingham Chamber of Commerce has decided again to organise the International Foundry Trades Exhibition in 1926, upon the same lines as the previous two successful exhibitions held in 1922 and 1924.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—The East Midland District meeting of the Institute is to be held at the Town Hall, Mansfield, on Thursday, September 18. A programme has been arranged, extending from 10.15 a.m., when an Executive Committee meeting will take place, until 4.30 p.m., when, after tea at Carr Bank House, a paper will be read by Mr. W. Warde Thompson, A.M.Inst.C.E., Mansfield. Members are requested to intimate their intention to attend the proceedings, not later than Saturday, September 13, to the District Secretary, Mr. Thos. Wood, City Engineer's Office, Town Hall, Leicester.

FIRE PROTECTION SERVICE AT THE BRITISH EMPIRE EXHIBITION.—II.

THE third large motor fire engine on loan for the fire protection service at the British Empire Exhibition at Wembley is illustrated in the general views, Figs. 12 and 13, below, while Figs. 14 to 17, on pages 384 and 385, show the construction of the engine, and Figs. 18 to 20 on pages 385 and 386 indicate the means of transmission of the engine power to the turbine pump; Fig. 21 shows the actual arrangement of the pump. This machine is by Messrs. Dennis Brothers, Limited, of Guildford.

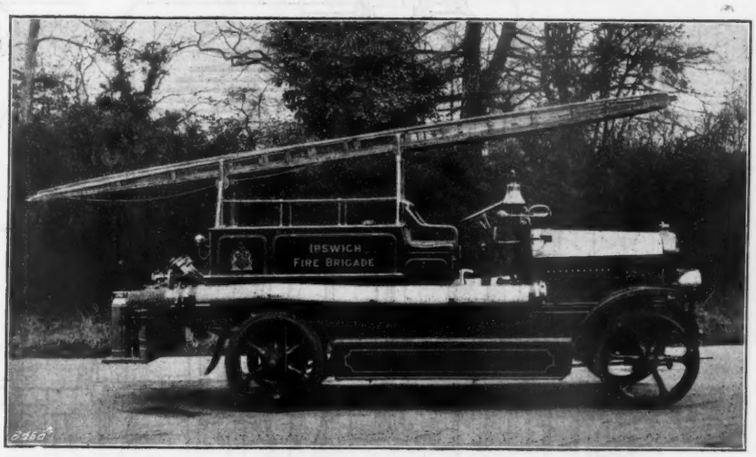


FIG. 12.

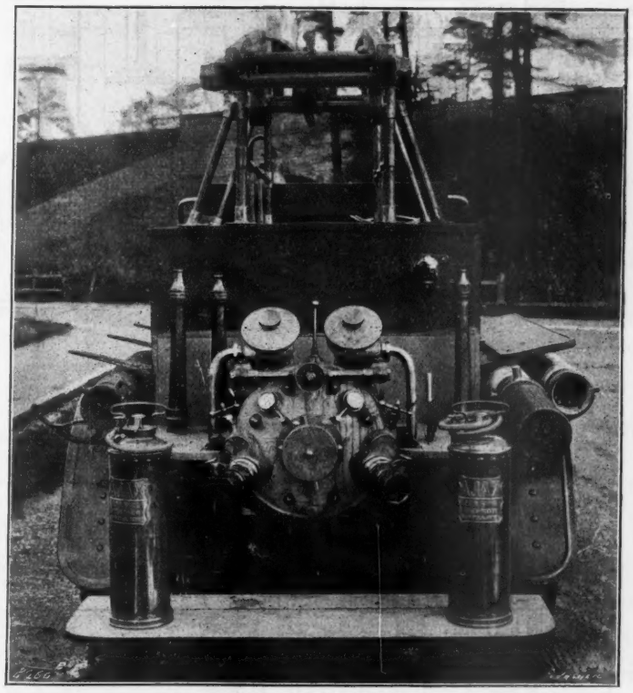


FIG. 13.

FIGS. 12 AND 13. 500/600-GALLON MOTOR FIRE ENGINE; MESSRS. DENNIS BROTHERS, LIMITED.

The engine is a four-cylinder one of 60 h.p. to 70 h.p., and the pump is capable of utilising its power to deliver from 500 to 600 gallons of water per minute. The customary features in the design of a high-class commercial chassis are to be seen in the vehicle, and the drive from the engine, of which the cylinders have a bore of 127 millimetres and a stroke of 180 millimetres, is taken through a cone clutch, with a composition lining, to a four-speed gear-box. At normal engine revolutions, a speed of approximately 35 miles an hour may be maintained when travelling, and the low gear is such that the machine is capable of ascending a gradient of 1 in 6 when fully laden. To obtain silent and reliable working, an overhead worm gear is fitted to drive the back axle. The pump is mounted at the rear of the chassis together with the exhauster or priming device necessary at starting. The drive for this is also taken from the engine in a manner described below.

The engine cylinders are cast in pairs, and the sturdy construction of the pistons is clearly indicated in the section through the first cylinder in Fig. 14. The crankshaft runs in five supporting bearings. From this crankshaft drives are taken to the two camshafts, one at each side of the engine, (see Fig. 15), which transmit motion to the valves through tappets. Rollers are mounted on the ends of the tubular tappets, the rollers running on the cams.

500/600-GALLON MOTOR FIRE ENGINE; BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. DENNIS BROTHERS, LIMITED, ENGINEERS, GUILDFORD.

Fig. 14.

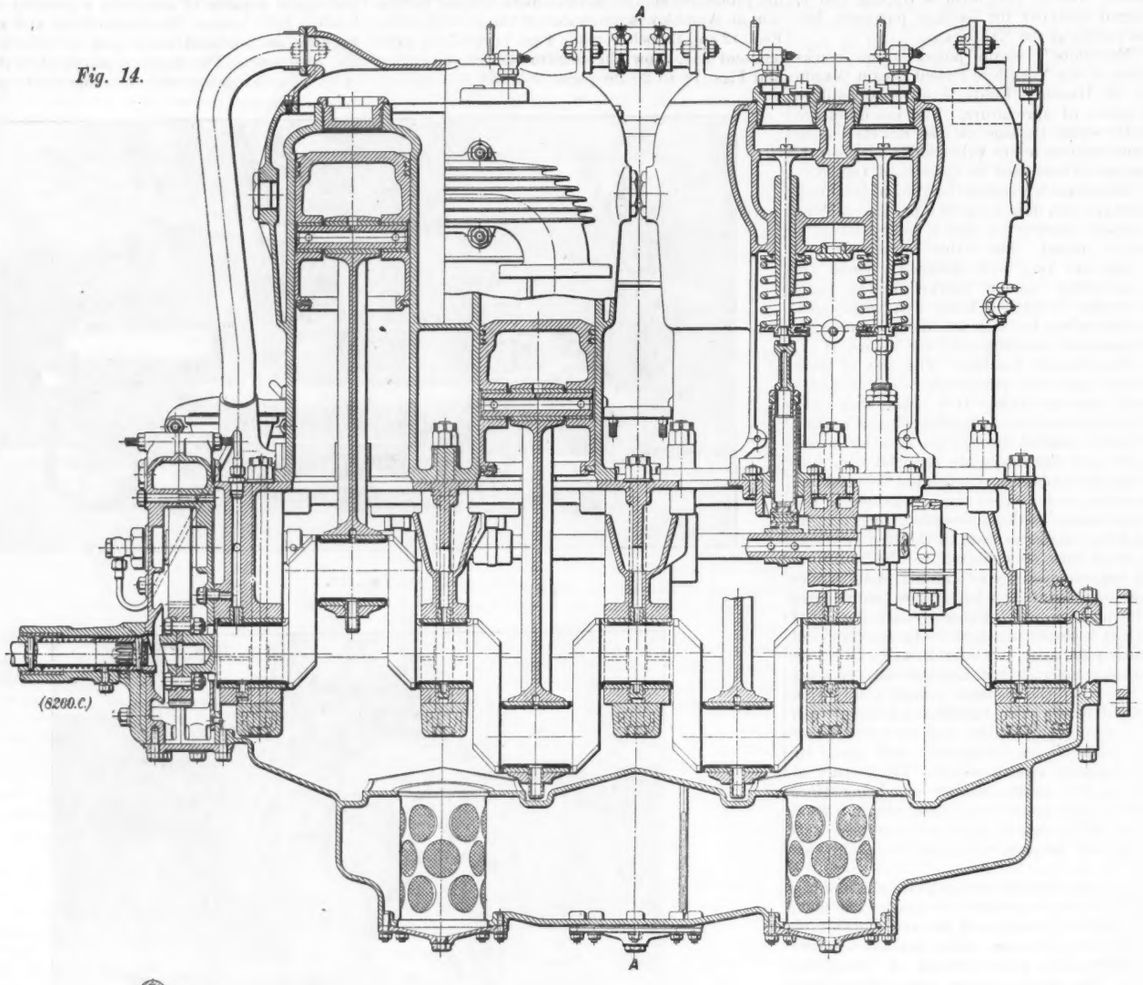
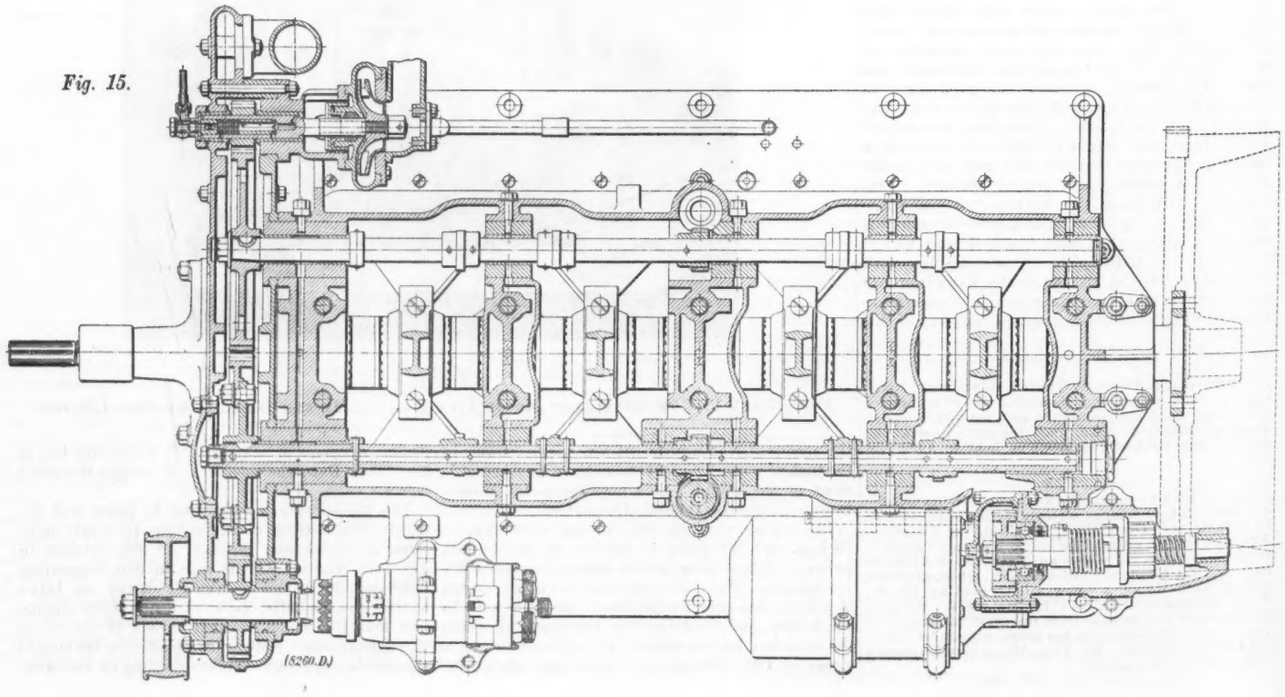


Fig. 15.



500/600-GALLON MOTOR FIRE ENGINE; BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. DENNIS BROTHERS, LIMITED, ENGINEERS, GUILDFORD.

Fig. 16.

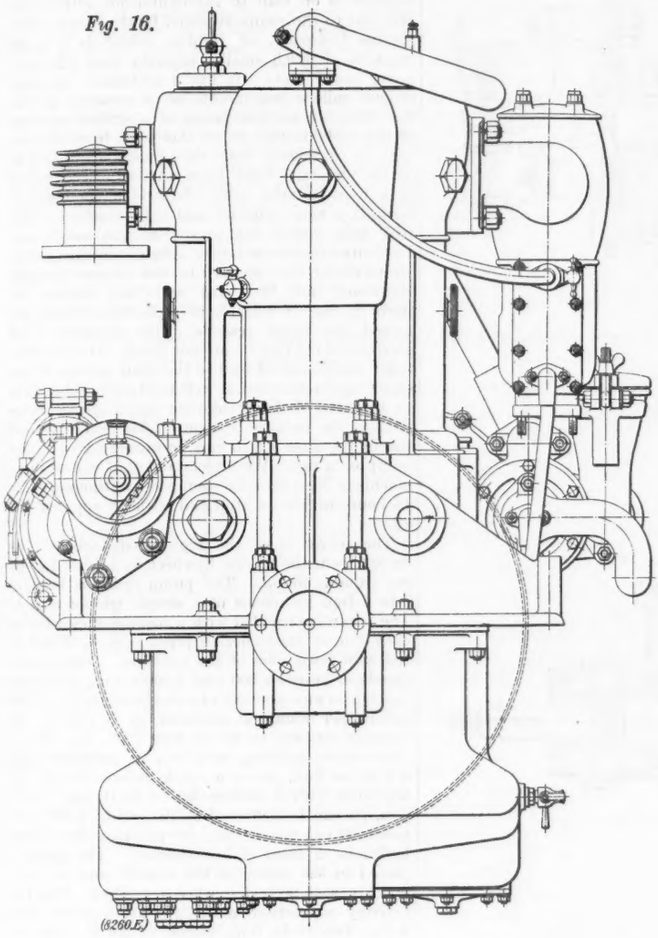


Fig. 17.

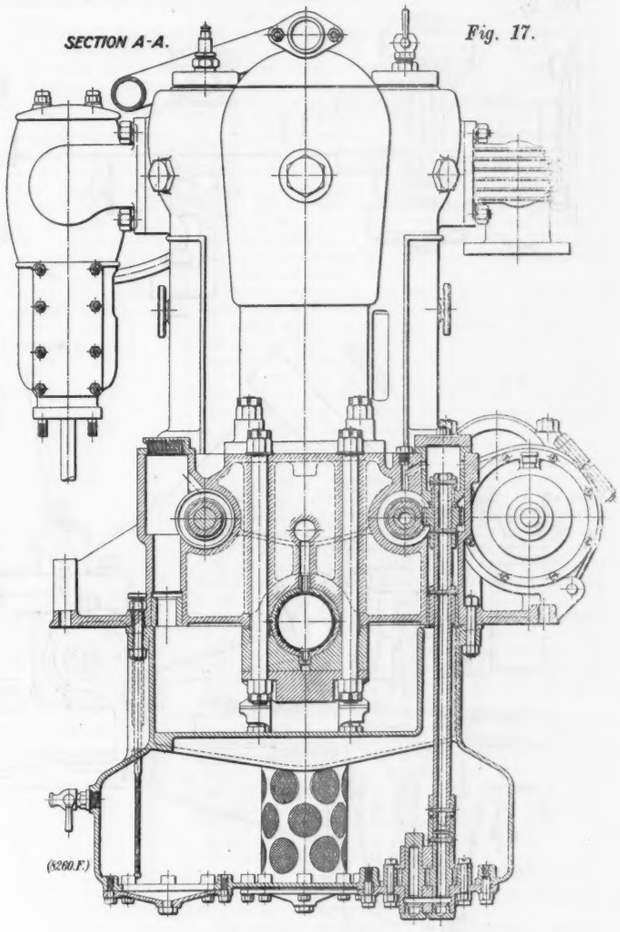


Fig. 18.

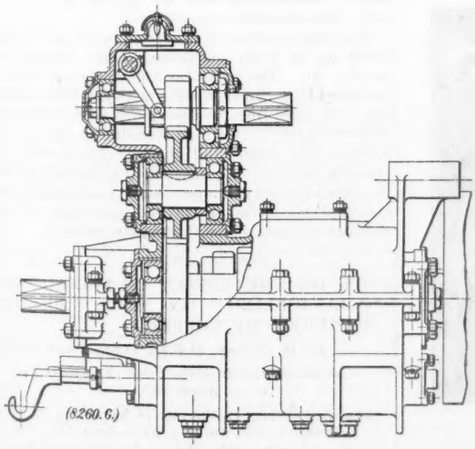
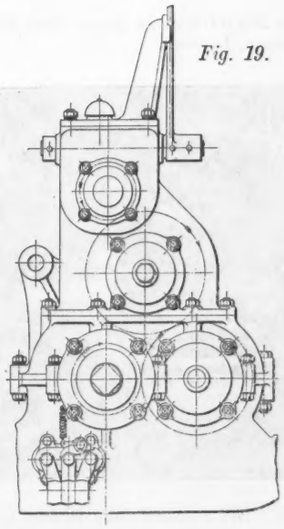


Fig. 19.



The latter are not solid with their shafts, but each is held in position by two taper pins. Adjustment is provided for the tappets so that they may be accurately set to give the required clearance. It will be noticed that the valve spindles are accommodated in extra long sleeves. The crank-chamber is provided with troughs from which the dippers on the connecting-rod ends throw up the oil. Before the oil is pumped back into the system of pipes by a gear-type pump, driven from the camshaft, as shown in the middle of the horizontal section through the camshaft bearings, Fig. 15, and also in Fig. 17, it is passed through two cylindrical filters with large gauze-covered openings. The pump for the jacket water is seen at the top of Fig. 15, and is driven from the timing gears. On the other side of the engine the magneto occupies a similar position. Starting is accomplished by the usual hand-turning or by the use of a motor-starter device, the latter being shown in Fig. 15. This, though not always fitted, is of the type in which the pinion is driven along a quick-threaded shaft when current is supplied to the electric motor. When this is done, the pinion engages with the teeth on the flywheel and turns it until such time as the explosions take place in the cylinders, when the drive is obtained from the engine and the pinion runs back out of action. A gear system is introduced between the motor and the driving shaft to obtain a reduced speed for the pinion.

The drive for the pump is taken from the gear box (see Figs. 18 and 19), in which the extra gear wheels are mounted for this purpose. The pump-drive pinion is put into gear for pumping by an operating lever, which slides the pinion along a squared shaft. The drive is taken through a shaft which is articulated with fibre-disc universal joints, the construction of which is shown in Fig. 20, on page 386. A support is provided for this shaft at its mid-length, by means of a ball bearing mounted on a cross-frame member. The fabric discs ensure that the pump spindle is free from any straining action likely to be caused by the deformation of the chassis frame under road running or pumping conditions. The priming device of the pump consists of two single-acting air pumps, set immediately behind the turbine pump and worked from the pump shaft through a clutch. These exhausters are capable of giving 26 in. of vacuum within half a minute of starting. The cylinders have quickly detachable covers, which give access to the exhaust valves,

while the pistons act as inlet valves, covering and uncovering ports in the cylinder walls. A three-way rotary valve on the front of the turbine pump enables the two exhausters to be worked together or singly, and also allows the air cylinders to be disconnected from the turbine pumps.

The latter has two stages, the water delivered from the one side being carried in the casing to the second stage on the other side of the pump (see Fig. 21). The design is very compact and the construction is entirely in gun-metal. Although giving a large delivery of water under pressure—actually it has been found capable of delivering 550 gallons at 120 lb. per square inch, and larger quantities at lower pressures, when working through $2\frac{3}{4}$-in. unlined hose—the weight is only about 4 cwt. The method of adjusting the pump gland is very simple and convenient. The output from the pump is carried to two hose connections after passing through rubber-seated non-return valves. The whole equipment is designed to be suitable for heavy and continuous working, and, in use, the Dennis fire engine has proved eminently satisfactory in the service of many public and private fire brigades.

Fig. 20.

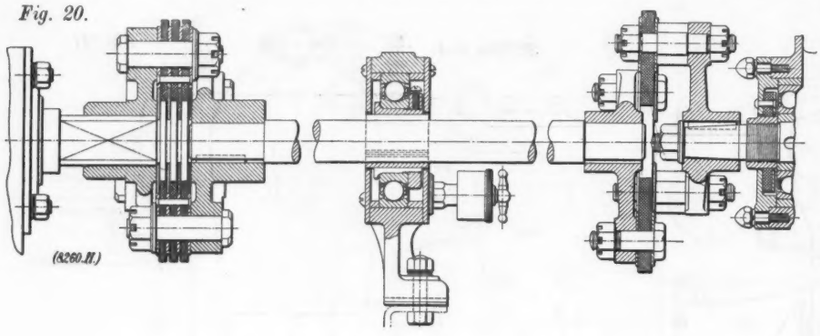
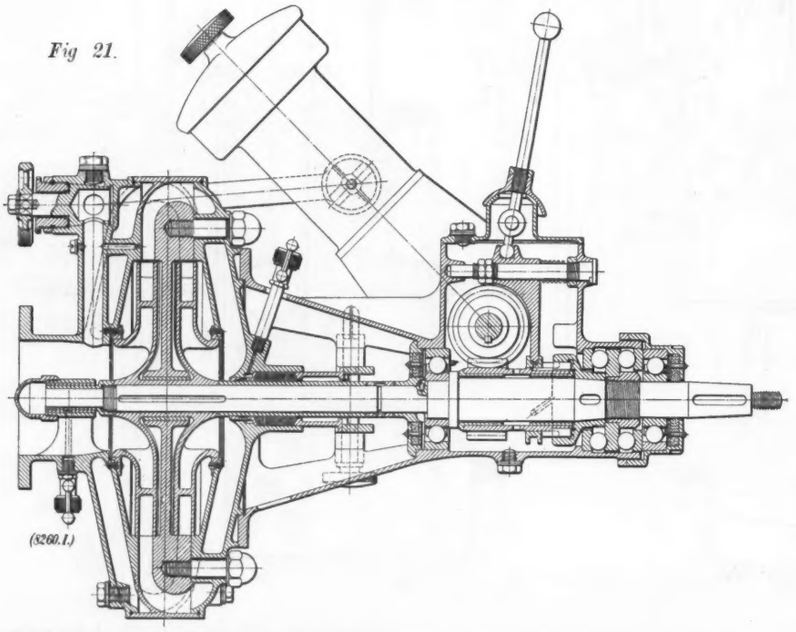


Fig 21.



FIGS. 20 AND 21. TRANSMISSION AND PUMP FOR 500/600-GALLON MOTOR FIRE ENGINE; MESSRS. DENNIS BROTHERS, LIMITED.

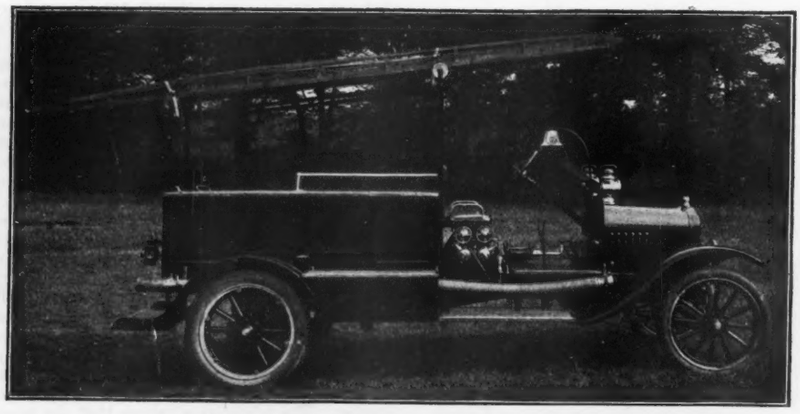


FIG. 22. 200-GALLON MOTOR FIRE ENGINE; THE STANLEY FIRE ENGINE CO.

Turning now to the smaller equipment, we notice first the only mobile unit of this class of which an example is on loan to the exhibition authorities. We refer to the engine supplied by the Stanley Fire Engine Company, of Halifax, which is a light machine of much smaller capacity than the foregoing motor units. It has a maximum capacity of 200 gallons per minute at a pressure of 120 lb. We give an illustration of a similar machine of this make in Fig. 22, on this page, from which it may be gathered that the chassis employed is of the standard Ford 1-ton pattern. The pump is a Rees-Roturbo unit, the whole combination forming a very compact and light machine which will take almost any ground in the well-known Ford cross-country manner. The advantages gained by adapting this chassis to the purpose include simplicity, low first cost and easy renewal of parts in case of wear or of replacement being required for other reasons. The standard Ford starter and lighting set are not fitted. On the other hand, additional oil feed to the front portion of the crank-case is provided, as well as oil cooling chambers on the base of the crank-case and a special water feed to the radiator system. This feed is passed through a filter which can be examined while the pump is in use. We understand that one of these machines has actually pumped continuously for 16 hours without a stop and without apparent ill-effect.

The pump is of the high-speed turbine type driven from the engine flywheel by enclosed gearing running in oil. The pump drive is brought into action by means of a simple friction clutch. The pump is provided with a suction connection on each side so that suction pipes may be fitted to either or both sides of the machine. With engine speeds of between 800 and 1,000 r.p.m., the pump can deliver any quantity of water between 50 and 200 gallons per minute at pressures up to 120 lb. Its capacity suffices to throw two $\frac{5}{8}$-in. jets over a three-storey building, or it can be employed with a $\frac{3}{4}$-in. or $\frac{7}{8}$-in. jet to a much greater height. It will work with a suction lift of 25 ft. and a good $\frac{5}{8}$-in. jet can be delivered at the end of 1,000 ft. of hose. It can also be used for pumping direct from hydrants in cases of low pressure. The pump is placed in the centre of the chassis and is consequently well protected when travelling. The two delivery connections are $2\frac{1}{2}$ in., the suctions being 3 in.; two 10-ft. 6-in. lengths of suction pipe are furnished, with copper-basket strainer, &c., as part of the outfit. The priming pump is a simple piston pump driven by "V"-type metal-to-metal wheels from the main pump shaft. The valves are of rubber composition and are placed in a small and easily detachable mounting.

The body is arranged to carry 8 or 10 men, about 1,000 ft. of hose, extension ladder, standpipes, nozzles, &c. The control of the whole unit can be mastered by a driver familiar with the Ford chassis in a very short time. The pump can be controlled while working by one man standing on the off-side between the pump and engine. The number of controls has been kept throughout as low as possible, in order to avoid all unnecessary complication, and the maker's claim as to the simplicity of the machine appears to be thoroughly justified.

NOTE ON THE EFFECT OF PROGRESSIVE COLD-ROLLING ON THE BRINELL HARDNESS OF COPPER.*

By H. MOORE, O.B.E., D.Sc., Ph.D.

(Communication from the Research Department, Woolwich.)

DISCONTINUITIES in the rate of hardening of copper by progressive cold-working have been observed by Alkins, Johnson, and others. In Johnson's experiments annealed strips 1·5 in. thick were cold-rolled to a final thickness of 0·033 in., and various properties were determined at numerous stages in the reduction. The Brinell hardness number rose from 40 in the annealed condition before rolling to 114 at 87 per cent. reduction in thickness, and then fell irregularly to

* Paper read before the Institute of Metals, London, on Wednesday, September 10, 1924.

93·5 at 97·8 per cent. reduction. A load of 500 kg. with a ball of 10 mm. diam. was used, and it is not quite clear that Johnson regards the accuracy of the tests on the thinner strips as being beyond doubt. Brinell tests were not made by Alkins, but, although he observed a discontinuity in the rate of increase, he found no fall in tensile strength in copper wire progressively cold-drawn to an area of cross-section of about $\frac{1}{750}$ of that of the original rod, and in each series the maximum reduction gave the highest tensile strength.

More recently, Rawdon and Mutchler have applied severe cold-rolling to copper, iron, tin and other metals and alloys, and state that the Brinell hardness rose rapidly during the initial stages of deformation and then diminished; "the metal becomes softer, and in its final form may be softer than the metal in its initial stage." These results would lead to the conclusion that, by severe cold-working, a metal could be brought into a state in which its hardness would be little or no higher than that of the annealed metal, and that, in this state, the metal could not be hardened by further cold-work. Such a conclusion would be of great practical importance, but appears so contrary to common experience that confirmation is necessary before it can be accepted as established. This confirmation was sought in the following experiments.

Electrolytic copper of high purity was melted, deoxidised with manganese, and cast in a chill mould. The ingot (containing 0·16 per cent. manganese), 3·5 in. square in section, was cold-rolled slightly, machined to remove surface defects, and annealed for 3 hours at 650 deg. C. The bar was cold-rolled from 3·12 in. thickness to 0·0125 in. thickness, one-half of the material being withdrawn and retained for testing after each reduction of 50 per cent. of the thickness. Immediately after each pass, the copper was plunged into cold water, rises of temperature up to 60 deg. C. being observed in the rolling. Brinell hardness determinations were made on the rolled surfaces, in dead-load machines. A ratio of load (in kilogrammes) to square of diameter of ball (in millimetres) of 10 : 1 was used throughout. Each Brinell hardness number given is the average of two to four tests with the same ball and load; there was good agreement throughout. Below the thickness of 0·8 in., the whole of the rolling and testing was carried out within a total time of 5 hours.

Details of rolling, testing, and results are given in Table I, and Brinell hardness numbers are plotted against reduction in thickness in the above diagram. Three methods of plotting are employed. The reduction in thickness is plotted in curve A as ratio of initial thickness to thickness after rolling, on an arithmetic scale, for comparison with the curves given by Rawdon and Mutchler; in curve B as the same ratio on a logarithmic scale; and in curve C as reduction in thickness per cent., this being the method used by Johnson, Alkins, and others. In curves A and C the points are inconveniently crowded at the two ends of the scale, respectively. The logarithmic plotting of curve B has the advantage that equal increments in length on this scale represent equal reductions, in proportion to the thickness at the given stage of cold-rolling.

It will be seen that an increase in Brinell hardness number takes place at each reduction to one-half the thickness, the total increase being from 48 for the annealed copper 3·12 in. thick to 130 when the thickness has been reduced to 0·0125 in., $\frac{1}{250}$ of the original thickness.

These results afford no support to the view that, on progressive cold-rolling, the hardness of copper falls considerably after rising to a maximum, as stated by Rawdon and Mutchler. In their experiments on commercial copper (the results of which are also shown in the diagram) the initial thickness was 0·4 in., the Brinell number reached a maximum at a thickness of 0·134 in. and then diminished fairly rapidly; the final thickness was 0·0015 in. Possibly the heat generated during rolling was sufficient to bring about a marked annealing effect, or the strip may have been too thin after a certain stage had been reached, comparatively early in the rolling, to give correct Brinell hardness numbers by the method used.

In the author's opinion, convincing evidence of any marked softening effect occurring generally in metals and alloys when cold-rolled, however severely, is still lacking.

The author's thanks are due to Mr. H. Waterhouse, who carried out the experimental work.

EFFECT OF PROGRESSIVE COLD-ROLLING ON THE BRINELL HARDNESS OF COPPER

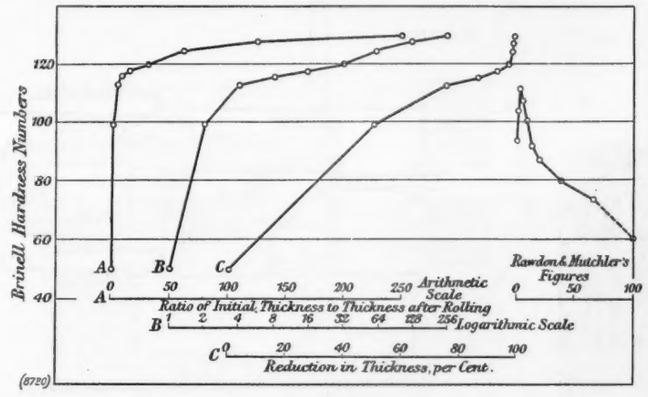


TABLE I.

T_o = initial thickness = 3·12 in. T = thickness after rolling.

Diameter of Rolls	Number of Passes.	Thickness after Rolling	$\frac{T_o}{T}$	Reduction in Thickness.	Brinell Hardness Numbers. Diameter of Ball. Mm. / Load. Kg. 5. / 250.	2. / 40.	1. / 10	0.8. / 6.4	Average.
Inches.		Inches.		Per cent.					
	(Initial thickness, 3·120)		1·0	0	48·6	48·5	..	..	48·5
30	5	1·560	2·0	50·0	98·6	98·5	..	..	98·5
30	3	0·797	3·9	74·4	113·0	113·0	..	..	113·0
24	3	0·400	7·8	87·2	117·0	116·0	..	..	116·0
24	3	0·210	14·9	93·3	118·0	118·0	118	119	118·0
24	2	0·101	30·9	96·8	..	120·0	120	120	120·0
15	8	0·052	60·0	98·3	..	125·0	125	125	125·0
15	5	0·025	125·0	99·2	..	..	128	128	128·0
15	5	0·0125	250·0	99·6	..	..	..	130	130·0

THE EXTRUSION OF BRASS ROD BY THE INVERTED PROCESS.*

By R. GENDERS, M.B.E., M.Met., F.I.C., Member.

(*Communication from the Research Department, Woolwich.*)

THE work already published by the author on the subject of extrusion† has dealt with the character of the defect which appears as a concentric core in the rod (termed "the extrusion defect"), and its relation to the peculiar nature of the flow taking place in the container of the press under the usual conditions, in which the pressure is applied at the end opposite to the die. The defect is ascribed to the turning inwards of the skin of the billet at the edge of the plunger, the surface of separation due to foreign matter in the billet skin following a characteristic path and reaching the die before the billet is completely extruded. Schweissguth arrives at the same conclusion. By extruding composite billets and analysing the process at different stages, he was able to show that, to obtain sound rod, only it is necessary to leave a discard in the container equal in length to its diameter. The effect of ordinary piping in the billet was found to be small in relation to that of the billet skin, and could be compensated by having the piped end of the billet next to the plunger and leaving an additional inch of discard. The formation of a shell of regular thickness in the receiver by the use of a false plunger head smaller in diameter than the bore of the receiver is recommended by Schweissguth for the avoidance of the defect, but it is stated that this has not been achieved, owing to the difficulty of securing true concentricity of the plunger head. The normal total discard of the process is stated to be 30 per cent. Doerinckel and Trockels followed Schweissguth's work with a number of experiments on billets built up from discs, which essentially confirmed the former work.

Despite evidence to the contrary, the opinion still seems to be held by some that defects in extruded rod are solely ingot defects, and therefore of the same character as those in rolled rod. No evidence has been presented, however, to support this opinion against the fact that the characteristic mode of flow which gives rise to the defect is found to be unaffected, whether the piped end of the billet is placed at the die or the plunger end of the receiver.

The method now commonly, but not universally, used by manufacturers is the extrusion of sound rod only, leaving a billet residue of 15 to 20 per cent. for remelting. Precautions against entry of the billet skin are also taken by the use of billets which closely fit the receiver and a plunger which can be centred so as to leave a uniform shell.

These measures appear to be the most effective of those which could be applied in existing presses, and must decrease very considerably the possibility of producing defective rod. Since, however, the mode of flow remains unaltered, any relaxation of the precautions or the presence of deep surface defects in the billet must inevitably lead to the production of the coring defect, while the avoidance of the defect involves a large percentag of scrap.

The method of overcoming the formation of the defect favoured by the author, consisted in completely altering the direction of flow in the receiver by inverting the process, so that the die was pressed into the billet, the rod being extruded through a hollow plunger. In small-scale experiments on brass, it was found that, under these conditions, no internal defect was produced, the billet skin piling up on the inner face of the die, and overflowing on to the surface of the rod only in the final stages. The method promised to be a solution of the difficulty and to be economical both in power and in material.

The present paper deals with a number of experiments carried out on a manufacturing scale with a press designed to extrude by the new method.

The Press.—An extrusion plant was required by the Indian Government factories, and, after making enquiries in various directions, the Ordnance Consulting Officer for India, Colonel Lawrence-Archer, recommended the adoption of the inverted process. The design and construction of the press were undertaken by Messrs. Henry Berry and Co., of Leeds, who first made as detailed a survey as possible of the extrusion methods in use in this country, satisfying themselves that a large proportion of discard was inevitable in the ordinary process, and that the pioneer task of making the first inverted horizontal press was likely to be justified by the possibilities of the new method.

The press specified was one of 900 tons power at $1\frac{1}{2}$ tons per square inch hydraulic working pressure, suitable for the extrusion of lead-free brass, and other alloys, to rod of diameters up to $2\frac{1}{4}$ in. The bore of the receiver was $6\frac{3}{4}$ in. in diameter and 27 in. in length, allowing the use of a billet $6\frac{3}{8}$ in. in diameter and 24 in. in length. In view of the experimental nature of the press, a working test was imposed requiring the successful extrusion of five billets of 60 : 40 lead-free brass to 1 in. diameter rod.

In preparing the design, the same margins of power and strength were allowed as in the case of a press working by the usual method.

The press consisted of two main cross-heads, one carrying the hydraulic cylinder and charging arrangement and the other holding the hollow plunger. The two cross-heads were connected by steel columns. These carried the container, which was movable either by means of the main ram or by two small auxiliary vicing or stripping rams. The charging arrangement consisted of a laterally-movable solid block, having attached to one side a cradle for the billet. On centring the cradle with the container, a small hand-operated pusher in the hydraulic ram can be used rapidly to charge the billet, and, by moving

* Paper read before the Institution of Metals, London, on Tuesday, September 9, 1924.

† "The Extrusion Defect," *J. Inst. Metals*, 1921, 26, 237; "The Extrusion Defect in Brass Rods Extruded from a Multiple Die," *ibid.* 1923, 29, 279.

the carriage across the press, the solid block or "gag" is interposed between the receiver and the hydraulic ram.

The receiver was of the usual jacketed type, and was heated by gas-burners. Fig. 1, on this page, shows the press as temporarily erected for testing. The essential features of the design are shown in the sectional drawing, Fig. 2.

Circumstances demanded that the tests should be carried out at Messrs. Berry's works, although they are not equipped for extruding. The maximum hydraulic pressure available at the works was 1,850 lb. which, allowing for the same pressure on the billet as in the ordinary method, necessitated the reduction of the bore of the receiver to 4⅞ in. for the purposes of the tests. The hollow plunger was 4⅝ in. in diameter, with a bore of 1½-in. diameter.

The sequence of operations is as follows: The billet to be extruded is placed on the ramp attached to the gag, which allows it to fall into the cradle cast on the side of the gag; the gag is then moved across the table to the stop, which brings the billet central with the container; the internal pusher is actuated by a hand-wheel rack and pinion and pushes the billet into the container.

The pusher is brought back, and the gag moved back against the end stop to close the container. The vice rams are moved forward to seal the container against the gag. Pressure is now applied to the main ram, which moves forward carrying the container and extruding the metal through the stationary plunger. When this is completed, the main cylinder is exhausted and the stripping rams pull the container forward to eject the discard at the back.

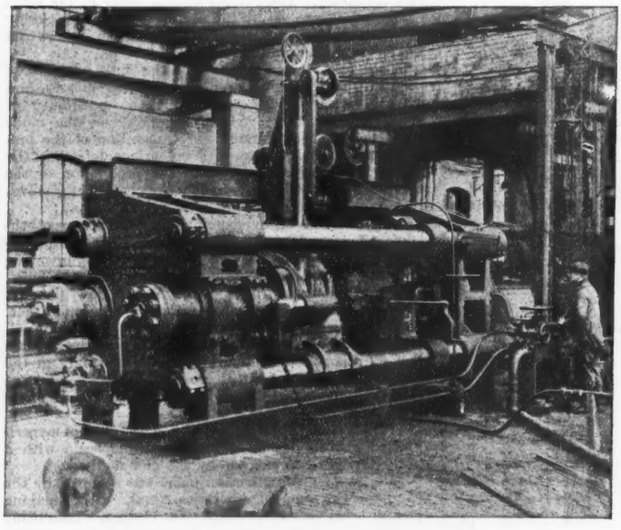


FIG. 1. PRESS, CONSTRUCTED BY MESSRS. HENRY BERRY AND CO., LEEDS, AS ERECTED FOR TESTING.

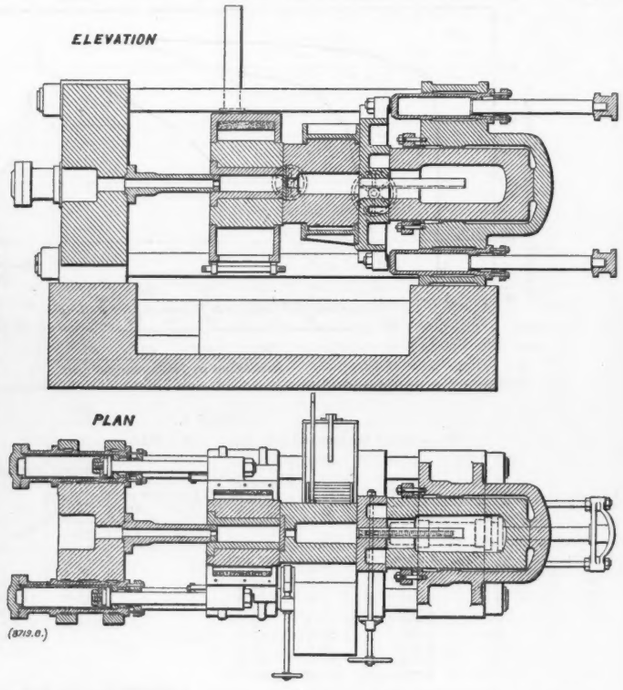


FIG. 2. SECTIONAL DRAWING ILLUSTRATING THE ESSENTIAL FEATURES OF THE DESIGN OF THE PRESS.

Extrusion of Billets.—The press was completed only a few weeks before the date of shipment, and this excluded any possibility of making an exhaustive investigation. In all, 24 billets were extruded, comprising 19 of lead-free 60 : 40 brass (4⅛ in. diameter by 24 in.), two of 57 copper, 41 zinc, 2 per cent. lead alloy, of the same dimensions, and three of 57 : 40·5 : 2·5 alloy (4 7/16 in. diameter by 23 in.). The latter three billets had not been cropped, and each contained a pipe 1½ in. in depth, but the remainder were ingots from which all trace of visible piping had been removed. The surfaces of the lead-free brass were good, but those of the lead-brass were defective, some having a potential "skin" of not less than ½ in. in some places.

The billets were heated in a gas-fired oven furnace, two at a time, and soaked for about 15 minutes at temperatures varying from 780 deg. C. to 830 deg. C. The time taken to charge—*i.e.*, from the opening of the furnace to the commencement of movement of the hydraulic ram—occupied from 20 to 50 seconds. It is estimated, however, that, in routine working with the furnace at a suitable elevation, charging could be regularly completed in 10 seconds. The temperature of the container was 150 deg. C. to 200 deg. C. A uniform central aperture in the die of 1 in. diameter was used throughout. Speeds of extrusion from 0·27 in. to 2·1 in. movement of the hydraulic ram per second were employed. The die was not attached to the hollow plunger, being inserted in the container from the opposite end and pushed into contact by a bar.

The whole of the operation of the process was carried out by workmen, none of whom had previously seen the extrusion of metal.

The first step was the extrusion of as much of the billet as possible with the object of ascertaining the mode of flow and the degree to which the rear portion of the rod was affected by the oxidised billet skin, which, in the small-scale experimental work, collected on the die until all but about 5 per cent. of the rod had been extruded. A die which closely fitted the container was used, so as to leave a minimum thickness of "shell."

The inner face of the die was flat, with a sharp edge to the aperture and at the periphery. Extruding 60 : 40 lead-free brass in this way, it was found that the billet could be reduced to a length of under 1 in., the pressure necessary only reaching the maximum at about 1½ in. from the end of the pressing in some cases, while in others the maximum was not required. The average pressure per square inch on the billet throughout the major portion of the stroke was about 16 tons to 21 tons. The surface of the rod was good over the forward third of the length, but after that was poor, the under side, coming from the lower part of the billet, showing longitudinal tears and small patches of oxide and dirt embedded in the metal. Fractures taken at different positions along the rod were all sound and showed no indication of the core defect. The extrusion of billets with a thick defective skin produced correspondingly worse surface defects, while billets from which the outer surface had been machined gave only a small number of slight defects. It was evident that the billet skin was not collecting on the die face to the large extent which had been anticipated. Small modifications, such as the machining of a step on the inner face of the die, did not appear to affect the flow to any appreciable extent.

A very thin shell, sometimes completely cylindrical, was generally left in the container, its weight averaging under 1 lb. This gave considerable difficulty, since it was too thin to be ejected with the die and billet residue, and was too tough to be broken away easily by prising from the container walls.

Improvement in all directions was obtained by reducing the overall diameter of the die. With a clearance of just under 1/16 in., a shell was left which was cleanly ejected with the billet residue. In many cases the die centred itself sufficiently to give a complete cylinder, and the surface of the rod was uniformly good.

When portions of the shell were missing, defects were produced in the corresponding portion of the rod. The further step of centring the die on the end of the plunger removed this difficulty and the resulting rod was uniformly good. The clearance given by a die of 4¼ in. diameter was somewhat too large, the shell being extruded round the edges sufficiently to lengthen it considerably and so increase the wastage to from 8 per cent. to 15 per cent. A total discard of 10 per cent. to 12 per cent. would appear a reasonable figure for practical working on the lines indicated.

The brass containing lead, which is probably the material most generally used in the extrusion process, proved much easier to extrude than the lead-free brass. The maximum power of the press was never required with this material, even when extruding down to a residue of ⅜-in. thickness. The average pressure used was 15 to 17 tons per square inch on the billet, representing a considerable economy in power over the ordinary method, in which a pressure of 25 to 28 tons is understood to be required under similar conditions.

The effect of varying speeds of extrusion was not great within the range of 0·5 to 1·5 in. per second movement of the ram. Very slow speeds, however, necessitated higher pressure, owing to cooling of the billet, while high speeds of about 2 in. per second produced a smooth blistered surface on the bar, which suggested that incipient melting had occurred. A speed of 1·0 to 1·5 in. per second was found most suitable, giving a good surface and reasonably good uniformity in diameter along the length of the bar.

Rounding the edge of the die aperture to a radius of about 0·02 in., appeared to give a somewhat smoother surface to the rod, and there was no indication of any effect on the power required for extrusion. A number of billets were partially extruded to leave varying lengths in the container.

Examination of Material.—Each billet residue, with attached rod varying from 3 in. to 2 ft. in length, was sectioned axially on the plane which was vertical in the press during extrusion, *i.e.*, at the position corresponding with minimum and maximum thickness of the shell. In addition, transverse sections were cut at each 5 ft. from the rear end of six rods, and at each 10 ft. in six others. The sections were pickled in 50 per cent. nitric acid.

The general features of the flow structure in the billet were similar to those shown by the specimens previously prepared on a small scale. No trace was found of the formation of any internal defect. The flow was entirely confined to a dome-shaped region adjacent to the die, about 1·2 in. in depth. The appearance is shown in Figs. 3 and 4, on page 389. Although, in Fig. 4, only 2·2 in. of the billet remains unextruded, there is no indication of flow except in the region of the die. Exactly the same flow pattern is found in a billet residue 12 in. in length. It would appear that, at the commencement of extrusion, the material flows along the curved formation indicated,

THE EXTRUSION OF BRASS BY THE INVERTED PROCESS.

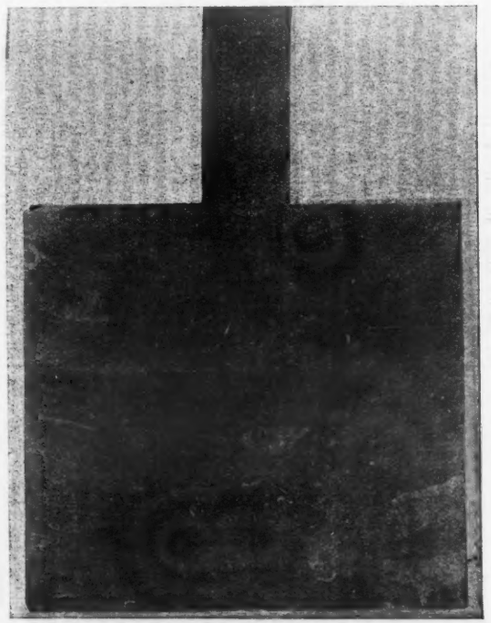


FIG. 3. SECTION OF BILLET EXTRUDED TO LENGTH OF 4·5 IN., SHOWING FLOW ONLY IN REGION OF DIE. ETCHED 50 PER CENT. HNO_3. APPROXIMATELY $\frac{3}{5}$ ACTUAL SIZE.

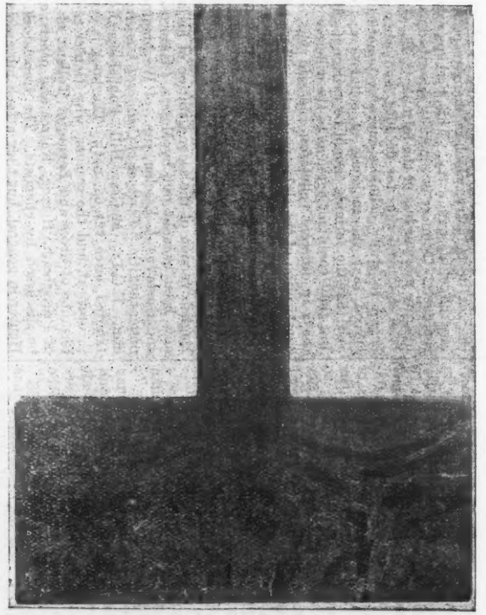


FIG. 4. SECTION OF BILLET EXTRUDED TO LENGTH OF 2·2 IN., SHOWING FEATURES SIMILAR TO THOSE OF FIG. 3. ETCHED 50 PER CENT. HNO_3. APPROXIMATELY $\frac{3}{5}$ ACTUAL SIZE.

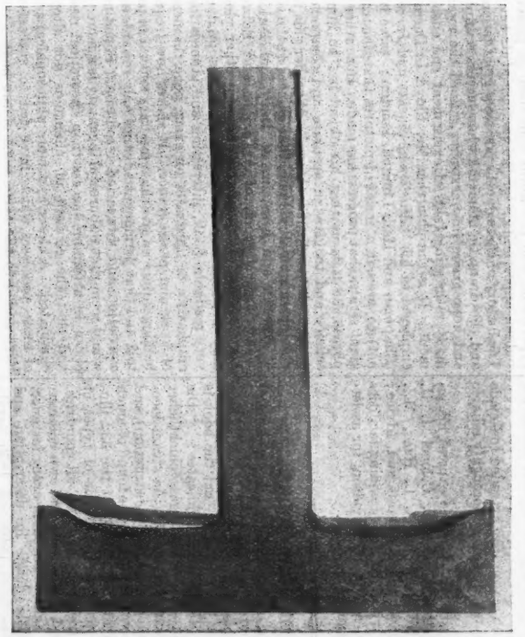
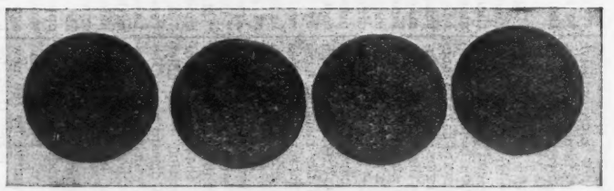


FIG. 5. SECTION OF BILLET RESIDUE, SHOWING PARTIAL ACCUMULATION OF BILLET SKIN.

a velocity gradient being established depending on the relative diameters of billet and die aperture. These conditions remain constant throughout the pressing until near the end, when the rear surface of the billet comes within the region of flow. At this stage the proximity of fixed surfaces to all regions of the flowing metal must introduce increased friction. It may be noted that the observations of the pressure during extrusion showed that a rise occurred when the billet was reduced to a length about equal to that of the dome-shaped flow-region. When the billet is reduced to an extremely small length, about 0·6-in., flow is much restricted, except immediately forward of the die aperture, and the metal in that region is extruded before the rest, any further pressing resulting in the formation of a few inches of tube. Owing to the cooling effect of the large block of metal closing the container, it was not found possible to extrude the last thin layer of the billet on the large scale. The conditions appear to be such that the interior of the rod can only be composed of sound metal, and the economy in power is attributed to the fact that the metal is extruded at the point of application of the pressure, losses due to friction being minimised.

The emergence of portions of the billet skin at a relatively early stage, when using a closely fitting die, was found to be due to the one particular in which the flow formation differed from that in the small-scale experiments. In the small specimens, extruded with a closely fitting die, the billet skin appeared to collect in successive inclined layers, which moved gradually, retarded by friction, along the face of the die, and overflowed through the aperture at a late stage of the process. In some cases it was possible to detach from the forward face of a partially extruded billet an annulus composed entirely of the drossy material comprising the original billet skin. In the large-scale specimens this movement along the face of the die had not occurred in the same manner. Resting on the die face was a thin layer of clean metal. The dirty material from the billet skin, although showing some tendency to accumulate, had found a flow path over this layer, along which friction would be comparatively small, so that the surface of the rod became affected at a correspondingly earlier stage. The provision of a step on the die (as shown in Fig. 5) produced more pronounced inclination of the layers relative to the die and assisted accumulation to a small extent, but increased the thickness of the dead layer, which gradually extruded as a film covering portions of the defect, and the remedial effect as judged by the appearance of the rod surface was negligible. Comparison of the conditions under which the large and small-scale experiments were made leads to the conclusion that temperature effects are the important factor, apart from the possible large influence of relation of diameter of die aperture to diameter of billet. Tendency to flow of the character shown by the small-scale specimens might be induced by a number of methods which suggest themselves from a consideration of the principles governing the flow of viscous bodies. Unfortunately, the work could not be continued beyond the securing of data from the series of commercial billets, and the obviously certain remedies of centring the die and excluding the billet skin were applied in a few concluding tests in order to show that by sacrificing a little in the direction of discard, the surface of the rod could be made commercially



30 FT. 20 FT. 10 FT. 1 FT. FROM DIE.

FIG. 6. TRANSVERSE SECTIONS OF ROD, SHOWING STRUCTURE AT DIFFERENT POSITIONS ALONG LENGTH. ETCHED 50 PER CENT. HNO_3. APPROXIMATELY ACTUAL SIZE.

acceptable. It would not be justifiable without further evidence to predict how far it might be possible to perfect the process.

The effect of piping in the billet was to produce defects in the rod for a distance of about 3 ft. at the forward or rear end, according to the direction in which the billet was charged. At the forward end the defect was a split extending to the surface, and at the rear end an irregular internal fissure.

Mechanical Tests.—Tensile test-pieces 0·564 in. in diameter, machined from the bar (lead-free brass) at distances of 1 ft. and 30 ft. from the die, gave the figures shown in the accompanying Table.

Mechanical Tests on Extruded Brass Rod.

	—	Permanent Extension of 0·15 per cent. at —	Breaking Load.	Elongation on 2 in.	Reduction of Area.
		Tons.	Tons.	Per cent.	Per cent.
20	1 ft. from die ..	13·4	29·9	48	68
	30 ft. from die ..	7·1	25·6	55	56
23	1 ft. from die ..	10·0	29·1	51	67
	30 ft. from die ..	6·8	25·4	58	60
24	1 ft. from die ..	12·2	29·6	49	66
	30 ft. from die ..	6·8	25·2	61	59

Brinell hardness tests made with a ball of 2 mm. diameter showed that the forward half of the bar was uniform in hardness. In the rearward half the central region remained constant, while the outer region rose in hardness.

The mechanical properties of the rod made in the experimental tests are probably not representative of material which would be produced in normal manufacture, where devices can be employed for the purpose of producing uniformity.

Structure.—The extreme forward end of the bar showed in all cases a grain-size similar to that of the billet. At a few inches from the end the structure became uniformly fine, little variation being found up to the middle of the bar. In the rearward half the same structure continued in the central region, which gradually diminished in diameter towards the rear end. The outer zone was extremely fine in structure. Fig. 6 shows the variation in structure in a series of sections cut at each 10 ft. from a typical bar.

Conclusions.—The experiments carried out on a manufacturing scale, although not extensive enough to constitute a complete study of the method, have provided ample data to show that the inverted process is incapable of producing internally defective rod when sound billets are used.

Precautions are necessary to secure good surface, the method adopted for the present being the avoidance of entrance of the skin of the billet into the region of flow. The consequent increase in the proportion of discard, although rendering the ejection of the billet shell more simple, brings the total discard above the ideal minimum of about 5 per cent., which might otherwise have been possible. Even so, however, the proportion is considerably less than in the ordinary method.

The observations of the relative pressures required by the two processes operated on a small scale are fully confirmed by the large-scale practice. For the same types of material, the pressure required by the new process is about 25 to 35 per cent. lower than for the ordinary process. This advantage must also be reflected in decreased wear and tear of the plant.

The structure of the extruded rod does not show the concentric zones of material, varying in crystal size and physical properties, often produced by the peculiar nature of the flow which obtains in the ordinary process. The rear portion of the rod is variable in structure and hardness from centre to outside, but in a continuous gradient.

For the manufacture of ornamental sections and other types of material in which absolute reliability is not essential or is subordinate to the requirement of immaculate surface, the advantage of the inverted method lies mainly in its saving of power. For certain purposes it may be limited to some extent by the dimensions of the hollow plunger, although it is estimated that with a 1,000-ton press a container of 8¼ in. diameter and a plunger of 5½ in. bore can be used.

For the production of engineering material, however, the inverted method possesses the advantage that all possibility of the occurrence of the "core" defect is excluded, and that, if defects are allowed to arise they will be visible on the surface of the rod. It is thus safe to extrude the billet nearly completely and so reduce scrap to a minimum without risk of the rod being affected internally.

The experiments carried out have been confined to the production of 1-in. rod, but no serious difficulty is foreseen in the application of the method to the varied practice of the modern works. Further work will be necessary before the method can be regarded as giving the best results of which it is capable. The experiments described have, however, been sufficient to confirm the previous small-scale work as regards the type of flow, internal soundness of rod, and the saving of power.

There seems to be no reason why extruded rod made by this process should not rank as a thoroughly reliable engineering material.

In conclusion, the author wishes to express his indebtedness to Dr. H. Moore, O.B.E., Colonel J. H. Lawrence-Archer, C.I.E., and Mr. A. L. Haas, M.I. Mech.E., for their encouraging interest and advice; to Messrs. Henry Berry & Co. for providing facilities for the tests; and to Mr. B. R. Davidson, for assistance in the examination of material.

NOTES ON NEW BOOKS.

PROFESSOR J. Jahn, of the Technical High School of Danzig, has no doubt bestowed a deal of conscientious work on his "*Dampflokomotive*" [Berlin; Julius Springer; price 4·30 dollars]; but the book is too precisely what its full title indicates: "Die Dampflokomotive in entwicklungsges chichtlicher Darstellung ihres Gesamtaufbaues" (the steam locomotive in the evolution of its general construction), and we are afraid that the volume will not be found of much more than historical interest. Most of the 332 illustrations of the 356 pages are diagrams of types of locomotives; the types are taken from all countries. The date is stated and the source—our own columns not infrequently—is acknowledged in every instance. But there is too little detail in description and diagrams; locomotives from 1840 and 1850 hardly require illustration, and the author practically seems to have ended his compilations with the outbreak of the war.

Many definitions of the word and position of foreman have been given, these varying considerably in their substance and clarity. Foremanship is a vastly more important job than it is frequently thought to be. The requirements for the position call for something more than is usually conceived—efficient craftsmanship and a fluent tongue. While the duties of foreman have not undergone much change, the industrial and commercial conditions are now so different that the carrying out of those duties presents very different problems, requiring great tact and discrimination. This is fully recognised by Mr. Grimshaw in his book, "*The Modern Foreman*" (New York: The Gregg Publishing Company), in the twenty-eight chapters of which the whole range of a foreman's duties is described and discussed. Amongst these are "The Art of Handling Men"; "Duties of the Foreman"; "Cutting out the Wastes"; "Modern Factory Methods"; "What the Foreman should Have"; "What the Foreman should Know"; "A Good Foreman in the Making"; "The Foreman Personally"; "Leadership"; "The Foreman and Labour." Each of these phases of the subject is dealt with in a breezy and easily-followed manner, there being sound common sense underlying most of the remarks. Under "A Good Foreman in the Making" Mr. Grimshaw says, "The foreman of to-day has opportunities for self-improvement far superior to those within reach of his predecessor of twenty years ago . . . Employers are beginning to see that he has been the weak link in the chain; that he has not, and the workers under him have not, clearly understood his responsibility and authority; and that he is an interpreter, not a buffer, between employer and working force." Too often is it assumed that craftsmanship is the chief if not the only qualification for foremanship. While efficient craftsmanship is eminently desirable it is probable that it covers much less than 50 per cent. of the total qualifications for foremanship. Man-handling, administration and organisation are no mean questions, and we venture to suggest that the weaknesses that foremen as a body may show are a reflection not of their incapacity but of the lack or appreciation by management of the importance of their duties. In a book of this size and on such a subject it is to be expected that the author's views cannot be accepted *in toto*. We take exception to one of the recommendations given because we believe it to be entirely wrong in principle. It is stated that "each foreman should receive a bonus proportionate to the total bonus sums in his department. When this is done, each foreman has an additional incentive to keep down the unit cost and the labour turn-over." In too many cases the experience has been that the foreman has been given a direct interest in high job rates; the higher the job rates the larger the workmen's bonus and, consequently, the larger the foreman's bonus. The book is one we can commend with confidence to our readers, to managers and directors, as well as to foremen themselves.

The progress of science, though continuous, does not proceed by equal steps. At times progress is accelerated by the vision of some genius; new horizons are opened before skilful inventors, fresh discoveries reward experiment, and the world finds itself in presence of sudden opportunities for the exercise of its activities. The history of these epochs possesses great fascination, and the dramatic moments when success rewards toil, and hope grows into certainty, afford the motive of many interesting tales of excitement and encouragement. It is the plan that Mr. Floyd L. Darrow has employed in his "*Masters of Science and Invention*" (Chapman and Hall, Limited, London; price 10*s.* 6*d.* net) to present a series of pictures that illustrate the giant strides that progress has made. In a rather vague phrase, he tells us that his object is "to humanise science and to give an accurate and comprehensive outline of its salient features." Whether this feat is possible in a small volume, that glances at the science of Newton and Einstein, of Davy and Perkin, of Henry and Marconi, of Arkwright and Edison, of Lamarck and Darwin, and of many other pioneers, may be doubted, but the author has produced a very readable book, interesting and stimulating. It emphasises or illustrates on every page the necessity of work and perseverance. It shows how frequently baffling failure awaits the temporary success of patient toil, and that permanent advance only rewards sincere conviction and unwearied resolution. Sometimes it would seem that resourceful ingenuity is a more potent factor in attaining success than theoretical research, and that the element of chance is not altogether eliminated. A closer and more philosophical analysis of those processes which have led to success would have added to the attractions of the book.

Chemists have sometimes been charged, and not without reason, with having started at a very late period to advance one of the oldest of all industries, the textile industry, which in many respects is virtually the cellulose industry. This, perhaps, explains the reproach. Cellulose is generally described as a carbohydrate more or less of the formula $C_6 H_{10} O_5$. It has been described thus for decades, and when chemists began to study cellulose more systematically, they agreed that the molecule of cellulose was complex and that the formula should be written $(C_6 H_{10} O_5) x$. But they could not agree as to the different values of the x in different celluloses, and still less as to the constitution of the single molecule. There have been researches on cellulose, especially in this century, and the colloidal character of cellulose has more and more been accentuated. But the first textbook on the chemistry of cellulose was, we believe, written by Professor Emil Heuser, of Darmstadt, in 1920. An English version of the second edition of his book has now been brought out by Messrs. Clarence J. West and Gustavus J. Esselen, jun., of Washington, D.C., under the title "*Textbook of Cellulose Chemistry*" (London, E.C.4: McGraw-Hill Publishing Company, Limited, price 12*s.* 6*d.* net). The book is essentially theoretical, and the reasons why Heuser rejects the formulæ of Cross and Bevan, of Tollens, of Hibbert, of Pringsheim, Herzog, Karrer and others, can only be discussed by chemists. The translators support Heuser in general, but they attach more weight than he does to the quite recent remarkable work of Irvine.

Though Messrs. Sulzer Brothers and the Borsig works of Berlin built an internal combustion-locomotive, with a four-cylinder two-cycle Diesel motor, as early as 1913, and Diesel engines have steadily been gaining ground, the Diesel locomotive has not yet become a railway tractor. The objections against it are want of simplicity and of flexibility and heavy weight. The problems are studied with special regard to electric propulsion by Dr. Ing. Herbert Brown, of Baden, Switzerland, in a pamphlet of 68 pages with 27 text-figures entitled "*Ueber Diesel-elektrische Locomotiven im Vollbahnbetrieb*" (Zürich: E. Waldmann). Reviewing the different systems of power transmission, toothed gearing, and hydraulic, compressed air or electric transmission, Dr. Brown comes to the conclusion that the Diesel-driven direct-current generator and motor offer the best solution of the problem. He pays particular attention to cooling, on which experiments were made in the works of Messrs. Brown, Boveri and Co., to control, to starting and stopping, and to economic features. Technically Dr. Brown considers the Diesel electric locomotive as equal to the steam-engine of equal power, apart from simplicity of construction and weight; economically he regards the Diesel-electric locomotive as inferior and as able to compete with the steam engine only when of high power (1,200 h.p. and more), and under special conditions. Conditions would be favourable in districts where coal is difficult to obtain and oil readily obtainable, where water is scarce and where heavy trains have to be moved on fairly level ground. The construction of higher-speed Diesel motors would shift the balance more in favour of the Diesel drive.

THE HARDENING OF STEEL.*

By WALTER ROSENHAIN, D.Sc., F.R.S., F.Inst.P.
(The National Physical Laboratory).

PERHAPS the best way of approaching the present position of the subject is to describe, as briefly as possible, some of the outstanding phenomena connected with the hardening and tempering of certain non-ferrous alloys, in order to show the analogy which exists between these phenomena and the well-know behaviour of iron-carbon alloys.

The fundamental discovery of hardening phenomena in non-ferrous alloys was that made by Wilm in the year 1909, when he showed that certain aluminium alloys containing a small percentage of magnesium were capable of hardening. This fact, as it subsequently transpired, had already been discovered in the laboratories of the Royal Arsenal at Woolwich, but, in accordance with the general policy pursued at that time in connection with War Department researches, had not been published.

The hardening which occurs in aluminium or its alloys containing magnesium differs markedly, at first sight, from that to which we are accustomed in the case of steel. Steel, when heated to a temperature above the critical point and quenched, is fully hardened as soon as it is cold. The aluminium-magnesium alloys, of which the well-known "Duralumin" may be regarded as typical, are not appreciably hardened immediately after quenching. On the other hand, the hardness of the aluminium alloy increases with time after quenching, if kept at the ordinary temperature. The hardening is rapid at first, but the rate falls off and the maximum value is reached generally after a period of about four days. This behaviour is illustrated by the time-hardening curve, Fig. 1.

The changes which occur in Duralumin and similar alloys, have formed the subject of extensive investigations which have been carried out mainly in this country at the National Physical Laboratory, and in America at the Bureau of Standards. Both groups of investigators have arrived at a satisfactory explanation of the phenomena, although their explanations differed in detail. Subsequently, these differences have been completely reconciled, and the transformations which occur in alloys of this kind during quenching and subsequent hardening are now thoroughly understood.

An early stage in the investigation consisted in the study of the equilibrium diagram of the alloys of aluminium and magnesium.†

Although the equilibrium diagram arrived at in this research differs considerably from earlier diagrams published by German and other workers, it did not exhibit any features which could account for the hardening of aluminium-magnesium alloys. The explanation was found in the discovery that silicon plays a part in the hardening of the alloys of aluminium and magnesium. Silicon is always present in commercial aluminium, and, indeed, the preparation of aluminium entirely free from silicon has not yet been achieved.

It was, however, found that in the aluminium magnesium alloys, when the amount of silicon was progressively reduced, the hardening effect was correspondingly diminished. It was also found that an alloy of the Duralumin type, as free as possible from silicon, showed very much less age-hardening than the normal material. In the search for the explanation of these phenomena, a study of the ternary equilibria of the system aluminium-silicon-magnesium was undertaken, but, owing to the immense amount of labour involved, only the region of special interest in the present connection, covering the alloys rich in aluminium, has been studied in detail. The results have been published in the eleventh Report to the Alloys Research Committee,‡ and more fully in a paper by Hanson and Gayler.§

It is unnecessary to reproduce here the equilibrium model and the various diagrams and sections which have been obtained by these authors. The point of principal interest is the existence of a well-defined compound of silicon and magnesium corresponding to the formula Mg_2Si, which is found to be capable of passing into solid solution in aluminium to a much greater extent at high temperatures than at the ordinary temperature. In thus thinking of the compound as passing into solid solution, it is not suggested that the compound as such is present in the solid solution, since it appears more probable, on general grounds, that silicon and magnesium atoms are scattered through the lattice of the aluminium crystals. None the less, when the amount of silicon and magnesium present reaches the limit of solid solubility, the excess appears in the form of minute crystals of magnesium silicide, Mg_2Si. Fig. 2 is a horizontal section of a portion of the ternary equilibrium model on which the limiting solid solubilities of silicon and magnesium, or of magnesium silicide in aluminium at a temperature of 500 deg. C., are indicated by the line x-y, the composition of the corresponding alloys being represented in the usual manner on a portion of the equilateral triangle forming the basis of the ternary model. For a number of alloys of varying compositions the increase of hardness, due to age-hardening after quenching, is indicated on the diagram by numbers which show the increase in tensile strength by hardening in each case. A very striking result is seen. The hardening power of the alloys increases steadily as their composition approaches the line of limiting solubility, x–y. The maximum increase of hardness is obtained in alloys lying close to this line, but increase of either silicon or magnesium, or both, beyond the amount which can be held in solid solution at 500 deg. C results in no further increase in hardening power. The inference from this result is clear, that hardening is associated with the amount of silicon + magnesium which is present in solid solution at the high temperature when the alloy is quenched. This quantitative connection between hardening power and the amount of magnesium and silicon held in solid solution can be clearly traced in a variety of other ways, which have been described in detail in the papers already mentioned. They justify the inference that the age-hardening of aluminium-magnesium-silicon alloys of suitable composition is due to the separation from a supersaturated solid solution, obtained by quenching from a high temperature, of magnesium silicide in a state of very fine division. Microscopic examination shows that these alloys, when quenched and examined immediately afterwards are homogeneous—that is to say, consist of crystals of a single solid solution only. After age-hardening there is no appreciable difference in microstructure, so that we are forced to the conclusion that the particles of magnesium silicide that have been deposited during ageing at the ordinary temperature are too minute to be traced by means of the microscope. On the other hand, if such an alloy be slowly cooled from a suitable temperature, so as to allow the excess of magnesium silicide to separate at a higher temperature, well-defined crystals of magnesium silicide are formed.

Fig. 1. TIME-HARDENING CURVE. DURALUMIN.

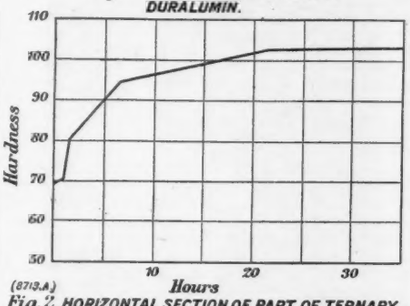


Fig. 2. HORIZONTAL SECTION OF PART OF TERNARY EQUILIBRIUM MODEL, SHOWING DIFFERENCES IN TENSILE STRENGTHS OF AGED AND SLOWLY COOLED SPECIMENS.

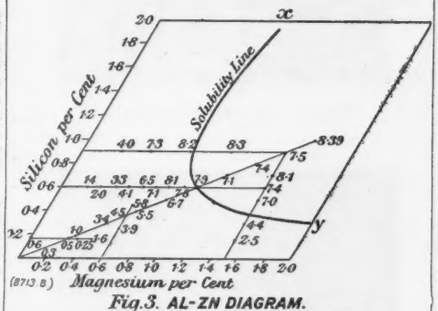
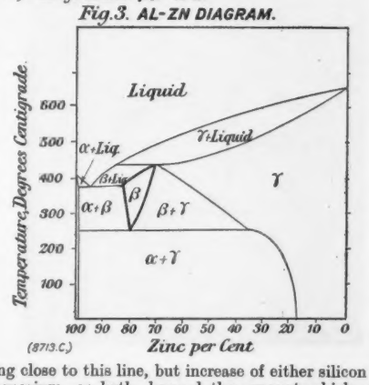


Fig. 3. AL-ZN DIAGRAM.



While the behaviour of aluminium alloys containing magnesium and silicon was being investigated at the National Physical Laboratory, a number of workers at the United States Bureau of Standards at Washington, including Merica, Waltenberg, and Scott, investigated the alloys of aluminium and copper from this point of view. Here also a solid solution is formed in the case of alloys containing less than 4 per cent. of copper, which can be rendered apparently homogeneous by quenching from a suitable high temperature after an adequate period of annealing to bring the copper into solid solution. If slowly cooled from that temperature, crystals of the well-defined and well-known compound $CuAl_2$ appear. If the alloy be quenched, the formation of these crystals is suppressed and the alloy appears to be a homogeneous solid solution. This also, on ageing, undergoes a certain amount of hardening, and the American investigators attributed this hardening to separation of very minute particles of $CuAl_2$ from the supersaturated solid solution. More recently Dr. M. L. V. Gayler, at the National Physical Laboratory, has examined certain groups of alloys containing aluminium, together with magnesium, silicon, and copper,* and has found that in these alloys age-hardening at room temperature is due essentially to the separation in a finely-divided state of magnesium silicide, MgSi, from the super-saturated solid solution formed during quenching. On the other hand, a further degree of age-hardening can be obtained by exposing the quenched alloys to temperatures in the neighbourhood of 150 deg. to 200 deg. C. for varying periods of time, and this further age-hardening appears to be due to the precipitation of the copper compound $CuAl_2$. The results of the two independent series of investigations are thus reconciled, and the explanation of the hardening of alloys of the Duralumin type, and of similar aluminium alloys in which supersaturated solid solutions can be formed by quenching, is placed on a satisfactory basis.

In the course of an investigation of the effect of impurities on copper being carried out for the British Non-Ferrous Metals Research Association, Hanson and Ford at the National Physical Laboratory have studied the alloys of copper with iron, so far as those consisting mainly of copper are concerned. In the course of this investigation the solubility of iron in solid copper was determined, and it was found that at 1,100 deg. C. copper could hold 4 per cent. of iron in solid solution, while at 750 deg. C. the solubility is reduced to less than 0·2 per cent. Consequently, if an alloy containing 0·7 per cent. of iron is held at a temperature of 1,000 deg. C. and then quenched, a supersaturated solution of iron and copper is produced. In this supersaturated solid solution at the ordinary temperature no further change occurs, nor would any such change be anticipated in view of the fact that at the ordinary temperature this alloy is some 1,000 deg. C. below the freezing point. When, however, the temperature is raised to about 500 deg. C. in order to allow of greater mobility, a change in the nature of age-hardening occurs. Measured in terms of Brinell hardness, there is a very appreciable change, the value increasing from 36 to 53, thus verifying the anticipation derived from the generalised view of the cause of hardening. In this particular case, however, there is not a corresponding increase in tensile strength, a fact which is possibly connected with the well-known peculiarity of copper in regard to correspondence between tensile strength and Brinell hardness. None the less, these alloys behave in the same manner indicated by the general theory, although, quantitatively, the results are disappointing.

A much more striking verification of the general theory, and one which presents remarkable analogy in detail with the iron-carbon system, has been discovered by Hanson and Gayler in the alloys of aluminium and zinc. These authors† have established for these alloys an equilibrium diagram which is reproduced in Fig. 3. The metallographic data upon which this diagram is based are so complete and have been so carefully determined that there can be no reasonable doubt of its validity, which has been further confirmed by a Japanese worker, Tanabe, using entirely different methods.

The portion of this diagram which is of particular interest in the present connection centres around a triangular area marked with the letter β. In this region of temperature and concentration the alloys, when equilibrium has been attained, consist of a single homogeneous solid solution. If they are kept at this

* Paper, abridged, read before the Iron and Steel Institute, London, on Friday, September 5, 1924.
† See ENGINEERING, vol. cx, pages 404, 788, 819.
‡ See ENGINEERING, vol. cxii, pages 594, 613, 624, 644.
§ See ENGINEERING, vol. cxii, page 519.

* See ENGINEERING, vol. cxiv, p. 394.
† See ENGINEERING, vol. cxiii, pp. 319, 538, 666.

temperature for a sufficient length of time and then quenched, and immediately examined microscopically, they are found to consist of an aggregate of simple polyhedral crystals. This microstructure is illustrated in Fig. 4, which has been obtained by very rapidly polishing the quenched specimen so that it could be etched 1½ minutes after quenching. If, on the other hand, such an alloy be cooled slowly, and particularly if its composition correspond with the lowest point of the triangular area in question, it exhibits a structure which is indistinguishable from the pearlite of carbon steel. This is shown in Fig. 5; as the diagram shows, we are here dealing with a typical eutectoid in every way analogous to pearlite itself, and the striking correspondence of the microstructure is a remarkable confirmation of this view.

FIG. 4. AL-ZN. 1½ MINUTES AFTER QUENCHING.

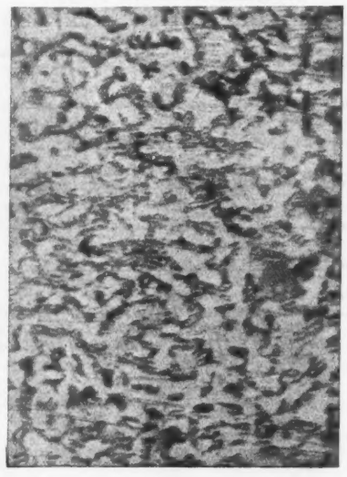


FIG. 5. AL-ZN. EUTECTOID.

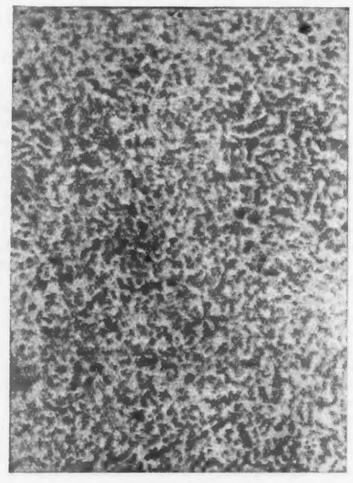


FIG. 6. AL-ZN. 2 MINUTES AFTER QUENCHING.

We have here, however, a case in which a supersaturated solid solution can be obtained by quenching from a suitable temperature, and if this supersaturated solid solution can subsequently be decomposed in a suitable manner, hardening should be anticipated. Actually, it is found that at the ordinary temperature the quenched supersaturated solid solution rapidly decomposes. If this process be studied under the microscope, a series of structures is found recalling in many respects the troostite and sorbite of carbon steel. Accompanying this is found first a rapid hardening followed by a gradual softening. These phenomena are well illustrated in Figs. 6 and 7, which represent the microstructures of transition stages, and in Figs. 8 and 9, which give time-hardness and time-temperature curves on specimens of these alloys taken immediately after quenching.

Fig. 8 shows that the hardness rises rapidly at first and then gradually falls. This series of changes is accompanied by a marked evolution of heat. On the basis of the general theory which has been outlined above, these phenomena can be readily explained. The supersaturated solid solution in this case at the ordinary temperature is too near its transformation temperature to remain in a metastable state, even for a short time. Consequently, the precipitation of the supersaturated solid solution, or rather in this case the breaking up of the metastable quenched β phase into the α and γ phases of the aluminium-zinc system, immediately commences. The first stage of this separation results in the formation, probably simultaneously, of very minute crystallites of α and γ in a state of extremely fine division. Such a structure brings with it a considerable increase in hardness. Were it possible to chill the alloys, as, for instance, in liquid air, at the precise moment when they have reached their maximum hardness, there is every reason to believe that they would retain this hardness so long as they were maintained at a sufficiently low temperature. Actually, the experiment has been tried of chilling the alloys immediately after quenching, and in that case no hardening occurs. The subsequent changes which the alloys undergo can be readily explained in view of the successive microstructures which are observed. The very finely divided α and γ phases coalesce into particles of increasing size with consequent diminution in hardness and a simultaneous evolution of heat. Ultimately, when the process has gone far enough, the hardness of the alloy is reduced very nearly to that of the original quenched solid solution. It will be evident at once that changes which occur after maximum hardness has been reached in these alloys are exactly analogous with the tempering of hardened carbon steel. Indeed, the whole of the phenomena, particularly in this system, are so closely analogous with those which are observed in steel that it is difficult to doubt that the same explanation is applicable to both.

The observations and inferences which have just been described with regard to non-ferrous alloys lead to the general view that hardening is the result of the breakdown of a supersaturated or unstable solid solution, such a supersaturated solution being obtained as a rule as the result of quenching. The question arises whether this general explanation of hardening is applicable to the special case of iron-carbon and alloy steels. There seems to be little difficulty in interpreting the phenomena which occur in steel in the light of these views. Actually, the analogy is so close that it appears to need little elaboration, but there are one or two outstanding points of difficulty which require consideration. In the first place, the hardening of a quenched carbon-steel occurs during quenching and not subsequently by any such process as age-hardening. Actually, it has been shown that there are changes which occur in quenched carbon steels even at the ordinary temperature, and Hadfield and Brusch have shown that there is a gradual evolution of heat in a fully hardened carbon steel, thus completing the analogy with the quenched aluminium-zinc alloys just described. The fact, however, that a quenched carbon steel is fully hard as soon as it is cold, points to a factor which requires full consideration when comparisons are made between different metals and alloys in regard to such a matter. The exact behaviour of any particular alloy when quenched and subsequently held at a constant temperature must depend upon two factors. The first of these is the rapidity with which transformations or reactions occur in the metal, while the second is the relative position on the temperature scale of the temperature at which the alloy is held after quenching. In the case of the aluminium-zinc alloys, room temperature is only some 240 deg. C. below the transformation temperature and only some 450 deg. C. below the temperature of complete fusion. In the case of the aluminium-silicon-magnesium alloys, the transformation temperature is considerably higher than in the aluminium-zinc alloys, while the fusing temperature is also somewhat higher. In the case of a copper-iron alloy the ordinary temperature is very far below the melting point, and this is still more so in regard to iron and steel. We should therefore anticipate, as is actually the case, that while in the aluminium-zinc alloys transformations at the ordinary temperature are very rapid, they are markedly less rapid in the aluminium-silicon-magnesium system, still less rapid in the copper-iron, and slowest of all in the iron-carbon system. Put in another way, one may regard various alloy systems as having "equivalent temperatures" at which the behaviour is analogous. It is therefore not surprising to find that in the aluminium-zinc alloys, for instance, tempering after hardening takes place at the ordinary temperature, while in iron-carbon steel temperatures from 350 to 500 or 600 deg. C. are required to bring about corresponding changes.

The fact that quenched carbon steels are fully hardened as soon as they are cold is a direct consequence of the well-known fact that it is impossible in straight

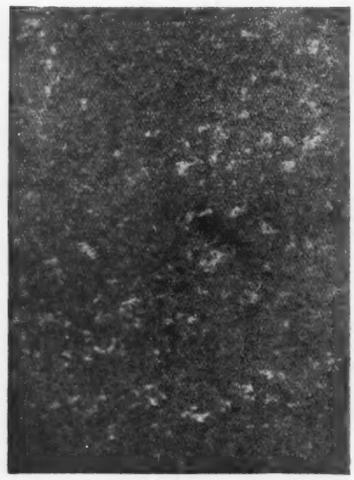


FIG. 7. AL-ZN. 5 MINUTES AFTER QUENCHING.

Fig. 8. AL-ZN. TIME-HARDNESS CURVES.

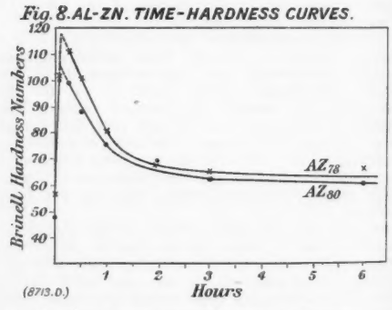
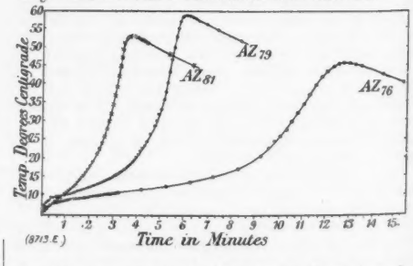


Fig. 9. AL-ZN. TIME-TEMPERATURE CURVES.



carbon steels to retain the alloy in the form of a homogeneous solid solution (austenite) by quenching, however vigorous. Expressed in terms of the views here described, this simply means that decomposition of the supersaturated or metastable solid solution occurs during the actual cooling process in the quenching operation itself. The validity of this view is confirmed by the fact that in the presence of suitable quantities of manganese or nickel, steels can be obtained in a fully austenitic condition by quenching, and that when thus retained in a state of homogeneous solid solution they are not hard. Further, such austenitic steels, if they are of precisely suitable composition, can be subsequently hardened or converted into the martensitic condition by raising their temperature, while further rise of temperature or prolonged exposure to heat results in tempering and again softening them.

If the explanation which has been found so clearly and readily applicable to the non-ferrous alloys also applies to the alloys of iron, the hardening of steel must be ascribed to the breakdown of the γ-iron solid solution (austenite) either by the deposition of a dissolved phase in a finely divided condition, or by the simultaneous formation of two phases also in a very finely divided state. Fully hardened steel would therefore consist of extremely minute but crystalline particles of α-iron and cementite in an excessively fine state of division. Such a state implies the existence in the material of a very large amount of intercrystalline boundaries. Whatever the nature of this boundary may be, there can be no doubt that an extremely fine aggregate of this kind must present enormous resistance to plastic deformation by any such process as slip. We have here the explanation, possibly, of the very much greater hardness which is obtainable in hardened steel as compared with the non-ferrous alloys of which we have spoken above. In the alloys of the Duralumin type, for example, we have in the usual hardened condition fairly large crystals of aluminium solid solution through which is dispersed a quantity of the compound Mg_2Si in an exceedingly fine state of division. The presence of an enormous number of these minute particles of a foreign body in the aluminium crystals must severely disturb their internal structure and interfere to a considerable extent with their ability to undergo plastic deformation by slip. It does not, however, by any means entirely destroy the mechanism of slip in these crystals, so that the resulting materials, although very much harder than in the annealed condition, are still appreciably ductile. By special treatment (prolonged heating at 200 deg. C.) the hardening can be carried further, until ductility almost disappears, but even then the degree of hardening is still much smaller than in steel. In an alloy of this kind complete hardening is not obtainable, because the maximum amounts of magnesium and silicon which can be held in solid solution do not yield a sufficient quantity of precipitated material after hardening, entirely to disrupt and destroy the crystal structure of the aluminium matrix. In the case of the iron-carbon alloys a different state of affairs prevails. Here the whole of the γ-iron solid solution undergoes transformation, and the simultaneous formation of minute crystallites of ferrite and cementite, possibly still more or less entangled with vestiges of the original γ-iron structure, results in a constitution in which a slip mechanism on any reasonable scale cannot exist. If such a structure is tempered—that is, if the particles are allowed to increase in size while they decrease in number—there will be a gradual reconstitution of a slip mechanism, at any rate in the ferrite crystals of the mixture, with the result that after a time an appreciable amount of slip mechanism can re-establish itself, so that we have with decreasing hardness an increasing degree of toughness and even of ductility.

On the basis of the views just explained, fully hardened steel (martensite) consists of a mixture of excessively finely divided ferrite and cementite. Such a structure is in accordance with the fact that steel in this condition is magnetic, and that under X-ray analysis it shows the atomic structure of ferrite. Without going into full details, it may be suggested that the majority of the properties of hardened steel can be readily accounted for by such a structure and constitution. There is, however, one outstanding feature in the microstructure of hardened steel which is not immediately accounted for by the explanation here put forward. This is the well-known acicular structure of martensite. In none of the non-ferrous alloys which have been studied in this connection has any closely analogous structure been observed. On the other hand, structures very similar to the needles of martensite can be found in other metals, which, while they do not appear to be capable of hardening, yet undergo allotropic transformations. Certain features which have been observed in the microstructure of cadmium by Jenkins, working at the National Physical Laboratory, show a striking resemblance to martensite, and are undeniably associated with the allotropic transformations of cadmium. At the same time, it may be pointed out that martensite having a well-marked acicular structure is not necessarily hard. In steels of quite low carbon content, which undergo no appreciable degree of hardening as the result of quenching, a well-marked martensitic structure is often developed, so that the connection between a martensitic structure and extreme hardness is perhaps rather accidental than causative. If the indications from the analogy of other metals can be trusted, one would be led to regard the acicular structure of martensite as associated primarily with the allotropic transformation of iron and only indirectly connected with the hardening process itself.

The explanation of the hardening of steel which has been put forward in the present paper has already been summarised in the words: "Hardening is due to the decomposition of a supersaturated or metastable solid solution obtained by quenching, such decomposition resulting in the production of a very large number of minute crystallites of one or more phases, either constituting the whole of the hardened material or scattered through a crystalline matrix." That a structure of this kind should possess, in some cases, an extreme degree of hardness is readily understood, since the softness and plasticity of metals in their ordinary condition are known to be due to the possibility of plastic deformation by a mechanism of internal slip in the crystals. Any disturbance of the regular crystalline arrangement results in a corresponding increase of resistance to slip, and therefore increase of hardness. If the disturbance of the structure be carried to the point where the slip mechanism is entirely destroyed or its functioning is eliminated, complete hardening results, and the degree of hardening in a given case will depend, in the first place, upon the exact extent to which the slip mechanism is disturbed, and in the second place, upon the actual cohesive strength of the metal in question. In hardened steel, both factors operate to produce maximum hardness. Iron itself, although very soft and ductile when in the pure state, possesses a high degree of cohesion; further, the simultaneous formation of α-iron and cementite during the decomposition of γ-iron, as a result of the allotropic transformation of the iron itself, brings about a structural arrangement most completely preventing the occurrence of plastic deformation by slip.

The relation of this view to earlier theories of the hardening of steel may be of some interest. It will be seen that the part played both by allotropic transformation and by carbon is fully recognised, since the allotropic transformation gives rise to the sudden change in solid solubility, while the presence of carbon is necessary to furnish one of the two decomposition products of the solid solution. In one aspect also the present view is closely connected with the so-called amorphous theory of hardened steel suggested by the present writer in 1914. The kind of disturbance of the crystal structure of a solid solution, which is produced by the formation in it of minute crystallites of a deposited phase, may be described as rendering the substance more or less completely amorphous in the immediate vicinity of each of these crystals. One of the main features of the amorphous state is the very absence of slip mechanism, which in the present view is regarded as being essential to hardness.

ON THE NATURE OF HIGH-SPEED STEEL.*

By MARCUS A. GROSSMANN and EDGAR C. BAIN
(Dunkirk, N.Y., U.S.A.).

(*Concluded from page* 348.)

Carbides in High-speed Steel.—It seemed desirable to secure some data as to the extent to which the various chemical elements in high-speed steel enter into the reactions involved in heat treatment. It was believed that if a piece of high-speed steel were quenched at a high temperature and then dissolved in a suitable chemical reagent, the alloying elements which had dissolved in the γ-iron or had remained in α-iron would go into solution in the liquid, while any residual carbides found would represent carbides still undissolved in the γ-iron phase after the heating of the steel for quenching. In the same way, the re-formation of carbides on drawing would ultimately lead to the formation of granules of such size as to resist chemical attack.

It is obvious that there is no justification for believing that the electro-chemical actions correspond quantitatively with the states of solution and precipitation of carbides in the steel. Indeed, it is altogether probable that, in the case of at least some of the carbides, the reagent can attack and decompose them the more readily as the size of the crystal aggregate becomes smaller and approaches molecular proportions. However, it is believed that the data presented give a good indication of the changes on going into solution as the quenching temperature is raised, and it may be assumed with safety that the general trend at least is as indicated for the drawing temperatures.

An electrolytic method for solution of the heat-treated specimens proved to be very convenient. The specimen was made the anode in a small electrolytic cell of about 1 litre capacity, using an electrolyte of 1 : 10 hydrochloric acid, and a copper cathode. A weighed specimen was electrolysed with a current of about 0·3 ampere for about 100 hours, changing the electrolyte at intervals of about 24 hours. Upon completion of the attack the still-undissolved stub was weighed, giving by difference the weight of steel destroyed. The "carbide residue" was filtered in an alundum crucible, dried and weighed. Although this did not represent the weight of true carbide residue from the steel (due to an intervening fact to be discussed later), the true carbide was easily estimated by a further procedure.

The steel selected for this series of tests had the following composition: carbon, 0·70 per cent.; tungsten, 18·50 per cent.; chromium, 4·17 per cent.; vanadium, 1·11 per cent.

The steel, in the form of commercial annealed $\frac{3}{8}$-in. square bars, was cut into pieces about 4 in. long. A series of these pieces was hardened after the usual manner of high-speed tools. They were quenched from a gas-fired furnace into oil; the reheating at the low temperatures was done in oil and at the higher temperatures in an electric "oven."

A group was heated at each of the following temperatures: 1,700, 1,900, 2,000, 2,100, 2,200, 2,300, 2,350, 2,400 deg. F. (926, 1,038, 1,093, 1,150, 1,205, 1,260, 1,288, 1,310 deg. C.), and quenched into oil. From each group one specimen was kept as quenched, and one was reheated to each of the following drawing temperatures: 300, 500, 700, 900, 1,100, 1,200, 1,300 deg. F. (150, 260, 390, 482, 593, 648, 705 deg. C.). There were thus 64 specimens in all. As a matter of incidental interest, the specimens, after heat treatment, were tested for Rockwell hardness.

The specimens were then subjected to the above electrolytic solution process. It was observed early that the specimens which had been quenched at the highest temperatures and had not been drawn showed a very considerable precipitate of tungstic oxide in the electrolytic cell, along with the true carbide residue. This appeared to have the possible significant interpretation that the tungsten carbide, when dissolved in the iron, went into solution atomically and not as a compound. It can, of course, be argued that tungsten carbide, if in solution in iron molecularly, would be subject to the same attack, because of the extreme minuteness of the crystal aggregate. However, the phenomenon is considered worthy of attention, especially because the amount of tungstic acid varies in close conformity with the heat treatment.

The carbides were analysed for total carbon, tungsten, chromium, and vanadium. Portions were also treated with ammonia and filtered, in order to determine in the filtrate the amount of tungstic oxide present with the carbide, as explained above. From these analytical data, and from the weights of carbide found undissolved, it was possible to compute the amounts of the elements which had been dissolved in the steel on quenching, and to discover the trend of their precipitation on drawing.

Analyses of the carbide in annealed steel gave the following probable average:—carbon, 2·3, chromium 6·3, tungsten 61·0, vanadium 3·6, iron (by difference) 26·8 per cent.

The amount of the carbide and its composition indicate that approximately all of the carbon, all of the tungsten, and all of the vanadium are in the form of carbide in the annealed steel; but it is interesting to note that only about half of the total chromium is in the carbide. Annealed high-speed steel, then, may be considered to consist of about 70 per cent. (by weight) solid solution of chromium in α-iron, and 30 per cent. complex carbide.

Of the maximum 30 per cent. carbide content, the most dissolved in any quench was about 13 per cent. Judging from the appearance of material A, it is conceivable that by heating the steel for a long time just below incipient fusion to secure rather complete diffusion of the carbide, it would be possible to dissolve about 20 per cent. carbide, leaving about 10 per cent. residual. The presence of eutectic in material A, which was solidified with such extreme slowness, precludes the probability that the carbide would be dissolved by any treatment. The solubility of the elements increases rather rapidly as the steel is heated in the higher ranges of temperature. On drawing these quenched specimens, the precipitation and re-formation of carbides leads to a gradual increase in the amount of "residual carbide." The analyses, after drawing, cannot be considered to represent accurately the amount of precipitated carbide, because the freshly formed carbide would in many cases be in such a fine state of aggregation as to be susceptible to electro-

* Paper, abridged, read before the Iron and Steel Institute, London, on Thursday, September 4, 1924.

chemical attack, and even though unattacked would be of colloidal size and pass through the filter.

The atomic percentage of the elements carbon, tungsten, chromium, and vanadium in solution, after quenching from 2,300 deg. F. (1,260 deg. C.), and followed by various draws, point to a most striking fact, namely, the relatively large amount of chromium in solution as compared with all the other elements. This follows not only from the lower atomic weight of chromium as compared with tungsten, but also from the fact that half the total chromium is already in solid solution in the annealed state. Unlike carbon, chromium is soluble in α-iron to a great extent.

Approximately the same relation among the elements is observed at all the different quenches, although, of course, the absolute amounts vary greatly.

Table I gives both in atomic percentages and in weight percentages the amounts of the elements in solution after successively higher quenches. Table II gives in similar units the amounts in solution after quenching at 2,300 deg. F. (1,260 deg. C.) and subsequently drawing at the temperatures stated.

TABLE I.—PERCENTAGES OF TUNGSTEN IN SOLUTION AFTER VARIOUS HEAT TREATMENTS.

Drawing Temperature.		No. Draw.	300 deg. F. (150 deg. C.).	500 deg. F. (260 deg. C.).	700 deg. F. (390 deg. C.).	900 deg. F. (482 deg. C.).	1,100 deg. F. (595 deg. C.).
Quenching Temperature.							
1,900 deg. F. ..	Weight per cent... ..	2·74	2·24	1·95	2·20	2·20	1·75
(1,038 deg. C.) ..	Atom ,, ...	0·92	0·76	0·66	0·74	0·74	0·59
2,100 deg. F. ..	Weight per cent... ..	4·75	3·75	3·50	2·70	3·18	2·95
(1,148 deg. C.) ..	Atom ,, ...	1·60	1·26	1·18	0·91	1·07	0·99
2,200 deg. F. ..	Weight per cent... ..	5·58	5·45	5·32	3·55	4·30	3·56
(1,205 deg. C.) ..	Atom ,, ...	1·88	1·84	1·79	1·20	1·45	1·20
2,300 deg. F. ..	Weight per cent... ..	8·20	7·33	7·02	6·88	6·28	4·20
(1,260 deg. C.) ..	Atom ,, ...	2·77	2·48	2·37	2·32	2·12	1·41

TABLE II.—PERCENTAGES OF THE ELEMENTS IN SOLUTION AFTER QUENCHING FROM 2,300 DEG. F. (1,260 DEG. C.) AND THEN DRAWING AT VARIOUS TEMPERATURES.

Alloying Element.							
Carbon	Weight per cent... ..	0·24	0·19	0·11	0·19	0·18	0·16
	Atom ,, ...	1·24	0·98	0·57	0·98	0·93	0·82
Chromium ..	Weight per cent... ..	3·31	3·35	3·30	3·33	3·18	2·85
	Atom ,, ...	3·95	4·00	3·94	3·97	3·79	3·40
Tungsten.. ..	Weight per cent... ..	8·20	7·33	7·02	6·88	6·28	4·20
	Atom ,, ...	2·77	2·48	2·37	2·32	2·12	1·41
Vanadium ..	Weight per cent... ..	0·62	0·61	0·60	0·58	0·46	0·35
	Atom ,, ...	0·76	0·74	0·73	0·71	0·56	0·43

The Hardening of High-speed Steel.—It would seem desirable, finally, to consider the mechanism of the hardening of a piece of finished high-speed steel.

High-speed steel, as has been seen, may be considered, for a first approximation, essentially a binary alloy, of which one constituent is a solid solution of chromium in iron, and the other the complex carbide of high-speed steel. The finished bar contains on an average 30 per cent. carbide, but this carbide is not evenly distributed. A little more than half of it is in the form of fine particles which have been precipitated from solid solution after the material solidified. Due to coring in the original dendrites, which has not been completely removed, there is a concentration-gradient from the centres to the edges of these areas which represent the original grains. The remainder of the carbide is in comparatively coarse particles, which represent the plates of carbide in the original eutectic. These are still present in fairly pronounced streaks throughout the piece. Consider this steel aggregate to be heated now to the usual quenching temperature for high-speed steel. The solubility of the carbide in the γ-iron increases rapidly as the temperature rises, so that at the highest temperature nearly half of the total carbide can be dissolved in the matrix. But owing to the immobility (the sluggishness of diffusion) of the alloying elements, especially the tungsten, there is formed an austenite whose homogeneity can never be much better than that of the annealed steel from which it formed. In addition, the fortuitous placing of the larger carbide particles from the original eutectic, causes small regional concentration gradients, which interfere further with the homogeneity of the austenite.

It is to be observed here that the particles of excess carbide exercise a very useful function in preventing grain growth at this high temperature. But for the obstructing action of these sluggish particles of excess carbide, grain growth at the high temperatures used for high-speed steel would be so rapid as to render the steel useless because of brittleness.

Having been heated suitably at the high temperature the steel is now quenched. In this quenching process a portion of the austenite is transformed to martensite, so that freshly-quenched high-speed steel shows, under the microscope, grains consisting of a mixture of austenite and martensite, and, distributed through them, the excess carbide particles that were not dissolved. A light etching reveals only the austenite grains and the excess carbide particles, but suitable further etching shows the martensite to be present very definitely. The relative proportions of martensite and preserved austenite undoubtedly vary from place to place, following the variations in concentration of the carbide. The regions lower in carbide would contain more martensite, and those richer in carbide more austenite. A piece of freshly-quenched high-speed steel is thus to be conceived as containing regions of austenite-martensite mixtures of widely varying stability. Perhaps over half of the steel, other than carbide, is austenitic after the quench.

These differences in stability also become noticeable on drawing the quenched steel. We have seen that a saturated austenite shows great stability on drawing, as evidenced both by the retention of hardness and by the lack of change in volume. But the austenite in ordinary quenched high-speed steel is not all saturated, and there are many regions where the concentration of carbide is much less than the saturation value. It is probably in these regions of lower concentration that the softening takes place which is observed in high-speed steel on drawing at low temperatures. These regions are predominantly martensitic, and on drawing at low temperatures the martensite decomposes and softens. Such low-alloy martensite resembles carbon steel martensite. The decomposition of this martensite can be traced both in the hardness and in the shrinkage, for we have seen that saturated austenite (material A), having very little martensite, retained both its hardness and its original volume on reheating as high as 900 deg. F. (480 deg. C.), whereas ordinary high-speed steel both softens and shrinks on being drawn in this lower range of temperature.

When the steel is now drawn at about 1,100 deg. F. (595 deg. C.) the phenomenon of secondary hardness is observed. The austenite regions are transformed, at least to a considerable extent, to martensite or troostite. The reaction takes place in all regions throughout the piece, although those with a lesser proportion of austenite (lower concentration of carbide) transform a little more readily and therefore at a slightly lower temperature than do the richer areas. The total effective hardening at 1,100 deg. F. (593 deg. C.) may be considered as representing the "algebraical sum" of the hardening effect of the transformation of the varied austenite and the softening of the various martensites.

It is well to emphasise at this point that the phenomenon of secondary hardness is by no means restricted to high-speed steel; and it is necessary to distinguish between secondary hardness and red-hardness. The retention of austenite on quenching is characteristic of many alloy steels on heating to sufficiently high temperatures. When such an austenite is reheated to low temperatures, secondary hardening sets in owing to the formation of sub-microscopic grains of α-iron and the precipitation of fine carbide particles. It is likely that if the tungsten in high-speed steel were omitted altogether the remaining elements alone would suffice to cause the retention of austenite and the appearance of secondary hardening.

The usefulness of high-speed steel is due, however, to the extent to which it exhibits the property of red-hardness, and it is here that tungsten plays its rôle. The large, heavy, immobile atoms of tungsten act by supporting the structure at these slightly elevated temperatures. Obviously, if the carbide elements—particularly tungsten—can migrate through the martensite to form large spheroids of carbide, then the source of hardness is lost. In steels with low alloy content this diffusion does occur, but the conclusion may be drawn that the tungsten atom is still too immobile even at a dull red temperature to diffuse through the distorted α-iron lattice so as to form the large carbide particles characteristic of annealed steel.

Conclusions.—1. High-speed steel solidifies very much after the manner of a 2 per cent. carbon white cast-iron, in which cementite is replaced by a complex carbide. It is outstandingly hyper-eutectoid.

2. The coring of the original dendrites, and the concentration of carbide at the eutectic regions, contribute to a lack of desirable homogeneity, which is then obtained only with the utmost difficulty, and rarely with completeness.

3. The original eutectic areas, which form the familiar carbide envelopes, break down readily, owing to their weak structure. Although these carbides are never present in very large solid grains, their original close association in islands makes thorough redistribution in the subsequent working difficult.

4. The martensite present in ordinary newly quenched high-speed steel is more difficult to recognise because small concentration gradients disturb the homogeneity of the original austenite grains. These concentration gradients are due to the coring of the original dendrites, and to the accidental placing of eutectic carbide particles throughout the mass.

5. The austenite formed in quenching high-speed steel, far from being decomposed completely on reheating at 1,100 deg. F (595 deg. C.), may to some slight extent persist even past 1,400 deg. F. (760 deg. C.).

6. High-speed steel contains about 30 per cent. by weight of complex carbide. In the annealed steel, approximately all the carbon, tungsten, and vanadium is found in the "carbide," together with about half of the chromium. Except in drill rods of high-speed steel there are distinctly two sizes of carbide particles, the fragments of the eutectic and the reprecipitated globules.

7. Under average hardening conditions somewhat less than half of this carbide is dissolved in the matrix on heating for quenching. Heating for a long time so as to approximate equilibrium conditions might possibly cause as much as two-thirds of the carbide to go into solution.

8. The solution of the carbides on heating begins at comparatively low temperatures and continues in a manner that would correspond with a modified A_{cm} line.

9. Hardening of high-speed steel is brought about by dissolving as much of the carbide forming elements as possible in δ-iron, and then reheating to form the hardest possible combination of martensite and submicroscopic carbide particles. The high temperature required for producing the rich austenite is not disastrous to grain size due to the obstruction offered by the residual carbide. The hardness is persistent at high temperatures as a result of the outstanding property of the alloy—the low rate of diffusion of the carbide elements.

PETROL.—It is interesting to note that just 21 years ago cargoes of petrol in bulk commenced to arrive in this country, and the transport and distribution in bulk has had a great influence in the development of motoring. From 33,000 tons in 1903 the import had increased to 402,000 by 1914, and the impetus given by the war during 1914–1918—an increase of 50 per cent. from the first to the last—pales into insignificance beside the somewhat unexpected increase in annual consumption from 597,000 in 1919 to 1,341,000 tons in 1923. These figures show that by the end of the first decade imports increased tenfold, whilst during the next decade another fourfold increase had taken place.

TREASURY CONTRIBUTIONS TOWARDS NEW EMPIRE WORKS.—A memorandum has now been issued for the guidance of applications for grants under Section II of the Trade Facilities Act, 1924. This, subject to certain conditions, makes possible a contribution by the Treasury of an amount not exceeding three-quarters of the interest payable in the first five years of the currency of a loan raised in the United Kingdom on behalf of any public utility in any part of His Majesty's Dominions. Contributions are only to be made to the Dominion concerned, and the capital sum on which they are based will be limited to the cost of materials to be purchased and manufactured in the United Kingdom. Details of the scheme and of its economic justification must be provided. Evidence must also be given that the scheme can be financed and that the prices are reasonable. When technical advice is required by the committee set up to deal with grants, the cost of obtaining the advice must be met by the applicant. Not more than 1,000,000*l.* can be granted in any year, or 5,000,000*l.* in all, under the scheme, and applications must be made to the secretary of the committee, at the Trade Facilites Act offices, 3, Bank Buildings, Princes-street, London, E.C. 4.

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The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

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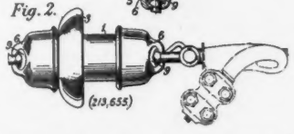
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

213,655. R. J. P. Briggs, London, H. S. Newman, Hanley, and Bullers, Limited, London. Insulators. (2 *Figs.*) December 30, 1922.—The invention is for improvements in insulators for supporting high-tension transmission cables. According to the invention, an insulator intended for supporting a high-tension transmission conductor is of the kind in which the body of the insulating material is tubular and in mechanical tension when the insulator is in the line, which insulator comprises a hollow cylindrical body 1 having a bore 2 running throughout its length, and two flanges 3, commonly known as "sheds," so disposed apart upon the cylindrical portion of the insulator as to leave a projecting portion 4 at each end. The open ends of the projecting portions 4 are closed by means of thin metal discs

Fig. 1.

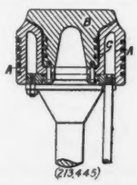
Fig. 2.



5 which are swaged over the ends thereof. A metal cap 6 is secured around each of the end portions 4 by means of a filling of cement. The metal caps are provided at their outer ends with sockets 9, one of which co-operates with means for supporting the power-transmission-cable and the other of which is provided with means for supporting the insulator itself. In the construction illustrated, the diameters of the sheds, the distance between the inner ends of the metal cups and the length of the bore 2 are so electrically balanced that should sparking-over occur, it would take place outside the insulator body in preference to inside the bore 2, *i.e.*, the shortest electrical path is arranged to lie between the inner edges of the metal caps outside the insulator. (*Sealed.*)

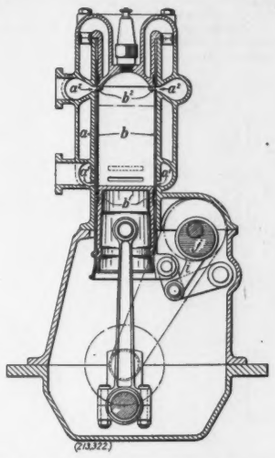
GAS ENGINES, PRODUCERS, HOLDERS, &c.

213,445. Swan, Hunter and Wigham Richardson, Limited, Walker, Newcastle-on-Tyne, and P. Belyavin, Jesmond, Newcastle-on-Tyne. Pistons. (2 *Figs.*) April 19, 1923.—The invention relates to the pistons of large internal-combustion engines in which difficulties commonly arise on account of the unequal distribution of temperature causing stresses which may give rise to cracks in the surface exposed to the hot gases. To overcome these difficulties in accordance with the present invention, the central portion of the piston is made in the form of a block B and is mounted within an outer water-cooled



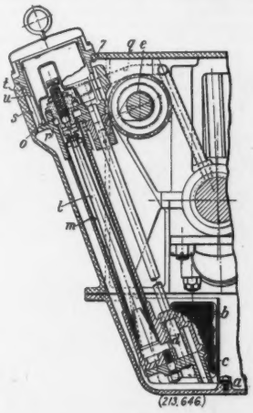
portion A, a slight clearance being left between the surface of the block and the water-cooled wall. There is interposed between the central block B and the surrounding cooled wall a number of expanding rings C, conducting heat from the uncooled central portion B to the cooled outer portion. The central piston block B is, therefore, cooled by the conduction through the expanding rings C, which permit of free expansion and contraction of the block, while providing efficient heat conduction through the metal expanding rings so that the temperature of the block is prevented from becoming excessive. (*Accepted April* 9, 1924.)

213,322. W. Newbery, Altrincham. Sleeve-Valve Internal-Combustion Engines. (3 *Figs.*) December 22, 1922.—The invention refers to four-cycle single sleeve-valve internal-combustion engines, and relates to engines of the kind embodying a cylinder and sleeve valve with exhaust and inlet ports at opposite ends, the exhaust port or ports being furthest from the engine crank. According to the invention, the engine cylinder *a* and the sleeve valve *b* are provided with inlet ports *a*1, *b*1 in the cylinder and sleeve valve, respectively, and exhaust ports *a*2, *b*2, the exhaust port or ports being at the end furthest from the engine crank and the inlet port or ports at the end nearest the crank. The ports *a*1, *a*2 in the cylinder lie at a slightly less distance apart than the ports *b*1, *b*2 in the sleeve valve and preferably extend a greater distance around the cylinder and sleeve than usual, while also, if desired, being narrower than usual. In addition to the gas-inlet ports *a*1, *b*1, there may be supplementary inlet ports in the cylinder and sleeve valve, respectively, which lie at a different angular position from the main inlet ports *a*1, *b*1, and are uncovered slightly in advance of the main inlet ports. Both the main and supplementary inlet ports may admit gas, or one gas and the other air. The usual eccentric *j* for moving the sleeve to cover and uncover the ports, instead of being arranged with its connecting rod *i* pointing away from the crankshaft, is arranged the reverse way, *i.e.*, with the



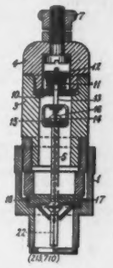
rod extending towards the crankshaft. The effect of thus reversing the eccentric and its rod is to cause the sleeve to uncover the ports for a longer period and thereby allow of a greater discharge of the exhaust and a larger admission of the incoming charge for given movements of the engine crank than when the eccentric and rod are arranged in the usual manner. (*Sealed.*)

213,646. S. H. Attwood, Lincoln, and Ruston and Hornsby, Limited, Lincoln. Force-Feed Lubricating Systems. (2 *Figs.*) December 27, 1922.—The invention relates to force-feed lubricating systems for high-speed internal-combustion engines. The lubricant in the crankcase *a* passes through a filter *b* into a sump *c* containing a gear pump *d*. The gear pump *d* is driven from the camshaft *e*. The oil from the pump is delivered through concentric filters *l*, *m* contained in a tubular chamber which connects the pump proper with a casing *r*, to a distributing chamber *o* at the top of the filters, from which



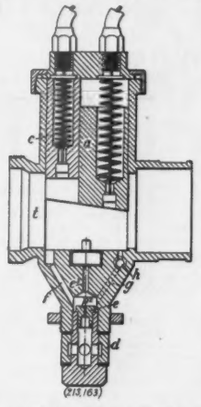
passages lead to conduits *q* for distributing the oil to the parts requiring lubrication. The casing *r* is fitted at the top of the crankcase in a socket *s* of cylindrical form which carries the conduits *q*. An annular channel *t* is formed in the exterior of the casing *r* and is in free communication with the interior of the crankcase 7 and through axially directed channels *u*, so that any lubricant which is forced above the level of the delivery passage over the exterior surface of the casing *r* will enter the channel *t* which at once directs it back to the crankcase. (*Sealed.*)

213,710. F. Reynolds, Walkerville, Newcastle-on-Tyne, and The Thermal Syndicate, Limited, Wallsend-on-Tyne. Sparking Plugs. (3 *Figs.*) January 22, 1923.—The invention relates to sparking plugs for internal-combustion engines in which the insulator surrounding the metal electrode is formed of fused silica. According to the invention, the insulator consists of a tube 5 of silica of very small diameter compared to the internal diameter of the casing 3. In the lower end of the insulator 5 a short length of platinum wire 22 is inserted forming the sparking electrode and is connected to another wire of less expensive material extending through the tube and electrically connected to the terminal 7 of the plug. Near each end of the tube a small collar 16, 17 is formed, each adapted to engage under spring pressure with a fixed metallic washer 15, 18. The washers and collars are suitably coned at their engaging surfaces, the washers 15, 18 being passed over the tube before the collars 16, 17 are formed on the latter. The lower cone 17 has the larger dimensions downward and the upper cone 16 its larger dimensions upwards. The washer 18 is held against the body of the plug by a gland nut 1, and a gas-tight joint is provided by the contact surfaces of the collar and washer. The upper washer 15 is supported by a metallic cradle 14 within the body 3 of the plug. The cradle 14 is secured to a screw-threaded metallic rod 13 passing through a washer 10 inserted between the body 3 and an insulating cap 4 screwed thereon; a nut and a washer 12 engage the rod 13, and between the washers is inserted a spring 11 which draws the rod 13 and cradle 14 upwards against the top collar 16 of the tube and the lower collar 17 of the tube against its fixed washer. Owing to the small area of the bearing surfaces, the explosion and suction pressures are both reduced to a minimum and the force exerted by the spring



(to resist suction) may be only a few ounces; this force can be adjusted to ensure a gas-tight joint at the seating of the lower washer under all working conditions. Under these conditions it is found that the tubular insulator may be placed under tension without risk of fracture. (*Sealed.*)

213,163. Brown and Barlow, Limited, Witton, Birmingham, and C. Brown, Birchfields, Birmingham. Carburettors (4 *Figs.*) June 14, 1923.—The invention consists of a carburettor for internal-combustion engines. *a* is the throttle valve, which valve slides in relation to the air-ingress aperture. *c* is the air-



control member and *d* is the float-chamber connection. *e* is the normally submerged main jet, which is compensated for by the air-release duct *f*, which, together with the pilot duct *g* and jet *h*, are connected to the normally-submerged chamber *y*2 situated above the main jet *e*, while *e*3 is the main-jet passage, which is surmounted by a gauze cover. (*Sealed.*)

HYDRAULIC MACHINERY.

213,061. W. G. Kent, London. Water Meters. (2 *Figs.*) January 1, 1923.—The invention relates to water meters of the type in which a cylindrical piston or displacer in a cylindrical chamber, having a radial diaphragm entering a slot in the piston, is moved by the passage of the water, so that its centre pin travels in a circular path around the axis of the chamber. According to the invention, there is provided a rotatable hub, having in it an annular groove, in which the centre pin of the piston works, so that friction is diminished and wear reduced. A is the working chamber, having fast on one point of its interior

Fig. 1.

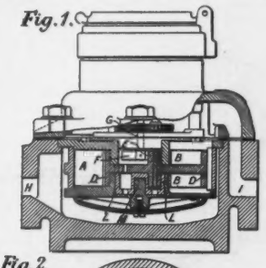
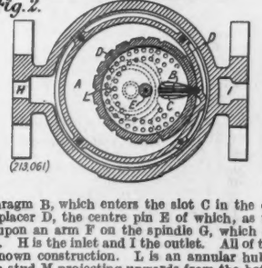


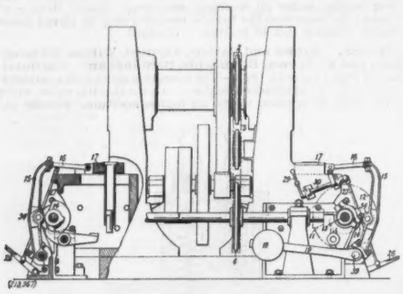
Fig. 2.



wall a diaphragm B, which enters the slot C in the cylindrical piston or displacer D, the centre pin E of which, as the piston moves, acts upon an arm F on the spindle G, which drives the counter-train. H is the inlet and I the outlet. All of these parts are of well-known construction. L is an annular hub which is mounted on a stud M projecting upwards from the bottom plate of the chamber, the hub being free to rotate about this stud, and the centre pin E of the piston fits loosely in this hub; thus, friction upon the centre pin of the piston is diminished and wear is reduced. (*Sealed.*)

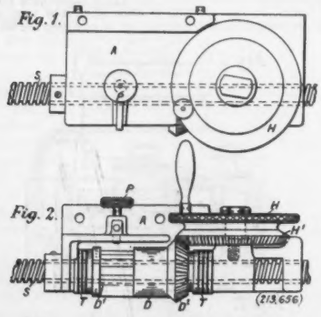
MACHINE AND OTHER TOOLS, SHAFTING, &c.

213,367. Guest, Keen and Nettlefolds, Limited, Smethwick, and E. Crosse, Cwmbran, near Newport. Vertical Heading or Forging Machines. (3 *Figs.*) January 25, 1923.—The invention relates to vertical heading machines for forging bolts, screws, rivets or the like of the kind wherein the heads are formed upon metal pins by subjecting the pins to one or more blows of a heading die, the heads being formed by means of shaped dies which are located in a slide mounted so that it can be reciprocated towards or away from a heading die; the pins are manually inserted into and manually removed from the dies when the latter have been moved away from the heading die. According to the invention, means is provided whereby the slide or slides of vertical heading machines of the kind referred to will be moved automatically, said means being driven from the shaft from which motion is taken to drive the shaft operating the ram or otherwise synchronised or timed to act in accordance with movements of the ram. The automatic movements of the slide or slides are imparted by means of cams and levers or other suitable mechanical devices. It is optional whether the slide is moved under the ram positively and similarly returned, or moved under the ram by means of counter-weights or springs and positively returned. In any arrangements, the movement of the slides in one direction is positive. In the other direction it may be positive or not. There is provided upon the crank shaft which drives the ram, a sprocket wheel 2.



At the lower part of the machine is a transmission shaft 3 which carries a sprocket wheel 4 and which is driven by a chain 5 from the sprocket 2 on the crankshaft. The transmission shaft 3 is provided at each end with a bevel pinion 11. Each of these bevel pinions 11 is in engagement with a bevel wheel 12 upon a short transverse shaft 13. Each shaft 13 is provided with cams 14 for operating upon rollers 34 carried by levers 15 which are connected by links 16 to the slides 17. The return movement of the levers 15 and slides 17 may take place under the influence of a spring or weight 18, so that the return movement may be interrupted if it is necessary at any time to prevent a slide from returning under the ram. In case of such an interruption, the power-operated mechanism for withdrawing the slides can continue to function without damage. The weights 18 are attached to levers 19 fixed to the ends of shafts 39. Upon the transverse shafts 13, additional cams are provided which each operate through a lever on a shaft, the usual ejector device fitted to the work-carrying tube in each slide. For interrupting the inward movement of the slides, when this is effected by spring, counterweight or the like, pedals 26 are provided, connected by links 27 to levers on shafts 30. The shafts 30 also carry levers 29 which operate plungers normally retained out of the path of the slides by springs. Upon operating the pedal 26, the plunger is pushed forward against the compression of its spring and thus moves into the path of the slide so as to arrest its inward movement. (*Sealed.*)

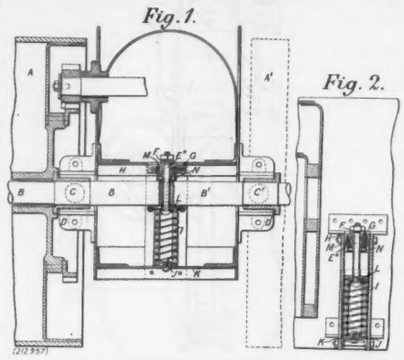
213,656. H. R. Milnes, Bradford, and J. W. Milnes, Bradford. Lathes. (2 *Figs.*) January 1, 1923.—The invention refers to what are known as lathe aprons on lathes of which the saddle is traversed by a leading screw. The invention consists in mounting on the leading screw S between ball-thrust bearings T, an internally-threaded one-piece nut D which carries,



or has connected thereto, a bevel pinion D2 to engage a bevel wheel H1 in connection with a hand wheel H. The mechanism is carried in connection with a frame or apron A attachable to the lathe saddle. When desired, the frame A carries a stud or stop P which may engage indents D1 on the nut to prevent the nut from turning. (*Sealed.*)

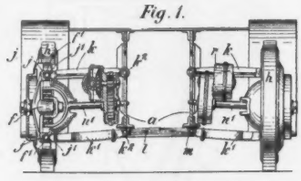
MOTOR ROAD VEHICLES.

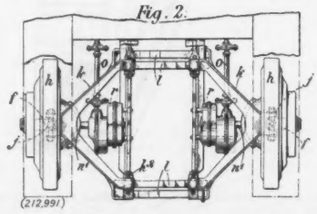
212,957. A. Wallis, Basingstoke. Road Rollers. (4 *Figs.*) July 16, 1923.—The invention relates to road rollers and has for its object to provide means whereby the inclination of the axles of the wheels with respect to the road surface can be varied in accordance with the camber of the road. According to the invention, the rear wheels of road rollers, or indeed the individual wheels of any pair, are each provided with a separate axle, which is pivotally mounted on the main frame about an axis which lies in the direction of travel in a vertical plane not inside the inner edge of the wheel, so that any tilting of the axle upon its pivot will not simultaneously raise or depress the outer and inner edges of the wheel. The wheels A, A1 are provided with separate axles B, B1, which have horizontal trunnions C,C1 journalled in brackets D, D1 secured to the main frame of the vehicle. The inner ends of the axles B, B1 approximate towards each other, but leave a sufficient clearance space for the purpose intended. A spring I, centrally situated below the inner ends of the axles B, B1, is compressed between a fixed abutment on a follower plate J secured to a transverse beam K and a loose follower plate L interposed between the upper end of the spring I and two inner ends of the axles B, B1. A second and lighter spring M is compressed between the upper surfaces of the inner ends of the axles B, B1 and an annular seating in a bracket G which is bolted to transverse beam H of the frame. The provision of a yielding or resilient abutment, such as the compressed spring I (with or without the auxiliary spring M), enables the axles B, B1 to assume inclinations in accordance with the camber of the road surface, and it will be evident that any equivalent



yielding abutment may be substituted for the spring or springs. The axles may be locked positively in the positions which they assume on a given road surface by means of a centrally-disposed threaded bush or sleeve F, which is screwed into a threaded hole in the bracket G until it abuts against a ring or washer N resting on the ends of the axles, and a bolt E°, which passes up through a gap between the ends of the axles and through the bore of the bush or sleeve F, the head of the bolt being tightened against the follower plate L by screwing its nut tight against the end of the bush F. On moving to a road surface of different camber, the nut of the bolt E° and the bush F are slacked off to allow the axles to assume the appropriate inclination, when the bush F is again screwed down into contact with the washer N and the nut tightened. (*Sealed.*)

212,991. G. Barker, London. Springing of Vehicles. (2 *Figs.*) December 21, 1922.—The invention is for improvements in the springing of vehicles. According to the invention, each radius rod is formed of two arms separately attached to the chassis at points widely separated in the longitudinal direction and converging towards the wheel. Bosses *f* are pivoted on vertical axes at f^1 to two lugs *j*, which are themselves hinged on horizontal axes at j^1 to the outer ends of two V-shaped frames *k*, k^1 hinged to the chassis *a* at k^2. These two frames are equal in width

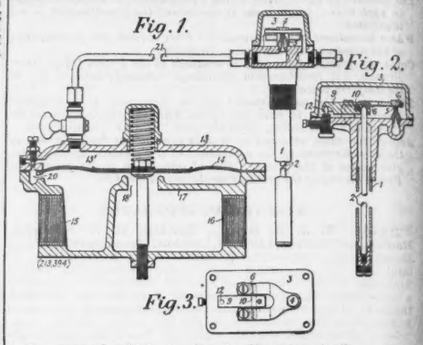




between the hinges j^1 and k^2. Two quarter-elliptic springs *l* are rigidly secured by their roots to the two inner ends of each lower frame k^1. These springs extend across the gap between the side frames of the chassis *a*, and are anchored at their tips, as at *m*, to the chassis. It will be seen that, by this construction, the frames *k*, k^1 are yieldingly controlled by the springs *l*, and that the boss *f* will move parallel to itself as the frames swing about their hinges. The road-wheels *h* are driven through universal joints. The road-wheel shafts n^1 are driven from the cardan shafts *o* through double-reduction gearings. These gears are mounted in casings *r*. (*Sealed.*)

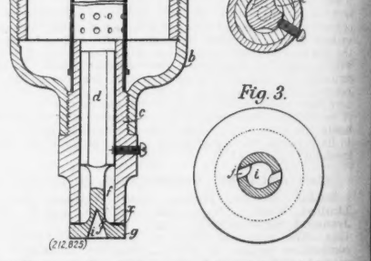
MISCELLANEOUS.

213,394. James Keith and Blackman Company, Limited, London, and G. Keith, London. Automatic Temperature-Control Apparatus. (3 *Figs.*) February 22, 1923.—The invention relates to automatic temperature-control apparatus of the type including a gas-regulating device responsive to the operation of a thermostat including elements 1, 2 of different coefficients of expansion, the element 2 of less coefficient of expansion acting through a motion-multiplying device in opposition to the stress of a spring at temperatures below that at which the thermostat device is designed to influence the gas-regulating device to hold apart a valve seat 4 and a nipple 5 serving for passage of gas from the gas-regulating device to a chamber 3 connected to the element of greater coefficient of expansion. In the apparatus of the invention, the motion-multiplying device includes a floating lever 9 engaged by the thermostat element 2 of less coefficient of expansion and presenting an abutment engaged by a flexible strip 6 fixed to the wall of the chamber 3 and operatively connected to the seat 4. The lever 9 is engaged near one end by the thermostat element 2, and at, or near, its opposite end by an adjustable stop-screw 12 threaded into the chamber wall. Between these points, the lever is provided with projecting pin 10 constituting the abutment aforesaid, the ratio of the lever arms being such that very fine adjustment of the device is obtainable by adjustment of the stop-screw 12. The gas-regulating device is of the type comprising a diaphragm casing 13, having on one side of the diaphragm 14 an inlet 15 and an outlet 16 for gas to be supplied to a heating apparatus, the inlet and outlet being separated by a partition 17 presenting a valve opening 18 controlled by the diaphragm 14



and a connection 20 by-passing the diaphragm to the compartment 13¹ of the casing on the opposite side of the diaphragm from which compartment a connection 21 terminating in the nipple 5 is taken to the gas chamber 3. In the present construction the by-pass connection 20 is through a part of the diaphragm 14 which does not cover the opening 18 in the partition 17. (*Sealed.*)

212,825. Babcock and Wilcox, Limited, London, and S. F. Weston, East Putney, London. Spraying Devices. (3 *Figs.*) August 16, 1923.—The invention relates to spraying devices more particularly intended for use in spraying with water ash and clinker hoppers. The improved spraying device is of the type comprising a tubular body, attachable to a water supply, with a plunger adjustable in the body, such plunger being grooved longitudinally to provide passages for the water between the body and plunger, and having a head adapted to cover the outlet end of the body, while providing between it and the wall of the tube a small interval permitting the water to pass radially outward in all directions. In accordance with the invention, the exposed surface of the head is formed with a conical central recess with passages tangentially disposed therein, leading from within the body to the recess so as to provide, in addition to the widely extending spray, a spray of smaller radius. The spraying device is shown attached to a water supply pipe *a* by means of a reducing



socket *b*. The spraying device comprises a tubular body *c* in which is fitted a plunger *d*, formed with a series of longitudinal grooves *e*, affording passages for the water between the body and the plunger. The plunger *d* is reduced at *f* to provide a space for the water passing the plunger to collect and with a terminal head *g* covering the outlet end of the body *c*. The inner surface of the head *g* is shaped, as shown, to provide for the gradual change of direction of the water, which is forced through the narrow interval *x* between the end of the body and the head *g*, and passes outward in a fine spray distributed over a wide area. The plunger may be moved axially of the body to increase or decrease this interval, and thus alter the fineness of the spray. The outer surface of the head is, according to the invention, formed with a conical recess *i*, which communicates by way of passages *j*, inclined and tangentially disposed in relation to the wall of the recess, with the interior of the body providing, in addition to the main spray, a separate spray of much smaller radius.—(*Sealed.*)

ELECTRIC FURNACES.—We understand that Wild-Barfield patent electric furnaces of over 25 kw. capacity, hitherto designed by Automatic and Electric Furnaces, Limited, of 173-5, Farringdon-road, London, E.C.1, will in future be designed in conjunction with, and supplied by, the Electric Furnace Company, Limited, of 17, Victoria-street, London, S.W.1.

INSTITUTE OF TRANSPORT.—Arrangements have now been made for the conference at the British Empire Exhibition to be held by the Institute of Transport on September 19. Accommodation will be reserved by the Metropolitan Railway on a train leaving Baker-street about 9.30 a.m. on that date. Visitors and members will assemble at 10.15 a.m. in the Pavilion of the Port of London Authority in Avenue 5 of the Palace of Engineering, at the eastern end. In the adjoining cinema theatre belonging to the Authority, a conference will be held at 10.30 a.m., over which Sir Henry P. Maybury, past president, will preside. Papers will be read, and a discussion will take place, after which luncheon will be served at 1.45 p.m. At 3.30 p.m., visits to the various parts of the Palace of Engineering will be made. A small number of applications to attend the conference can be entertained if sent immediately to the Secretary.